ABIOTIC AND BIOTIC HYDROLYSIS OF PARA-SUBSTITUTED ACETANILIDES CORRELATING MOLECULAR STRUCTURE WITH REACTIVITY

by

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ABSTRACT

The influence of substituents on rates of hydrolysis of para-substituted acetanilides was investigated. Second-order rate constants for the alkaline hydrolysis and bacterial biolysis of a series of para-substituted acetanilides were measured and correlations with substituent parameters were investigated. The compounds studied were acetanilide, p-bromoacetanilide, p-cyanoacetanilide, p-fluoroacetanilide, p-methoxyacetanilide, p-methylacetanilide, and p-nitroacetanilide.

Second-order rate constants for alkaline hydrolysis at 25°C were $1.15 \pm 0.07 \times 10^{-3}$ sec^{-1} M^{-1} for p-nitroacetanilide, $3.77 \pm 0.22 \times 10^{-5}$ sec^{-1} M^{-1} for p-cyanoacetanilide, and 7.25×10^{-6} to 8.90×10^{-6} sec^{-1} M^{-1} for the remaining five para-substituted acetanilides. Competing reactions (nitrile hydrolysis) or variations in mechanism (Meisenheimer complex formation) were found to lead to abnormally large hydrolysis rates for the compounds p-cyanoacetanilide and p-nitroacetanilide, respectively. The LFER with Hammett sigma values (σ_p) for the remaining five para-substituted acetanilides yielded a reaction constant, ρ, of 0.082. Thus, alkaline hydrolysis rates for these compounds were insensitive to substituent effects.

Bacterial biolysis experiments generated second-order rate constants ranging from 1.16×10^{-14} to 2.14×10^{-14} sec^{-1} org^{-1} L. for the seven para-substituted acetanilides using a pure culture of the genus Arthrobacter (sample CSMNS); 1.44×10^{-14} to 2.62×10^{-14} sec^{-1} org^{-1} L. using a pure culture of Arthrobacter (sample DSMP); 1.11×10^{-17} to 3.24×10^{-17} sec^{-1} org^{-1} L. using a pure culture of Pseudomonas (sample CCS); and 5.20×10^{-19} to 10.60×10^{-19} sec^{-1} org^{-1} L. using a pure culture of Bacillus (sample B.EPA). Similarly, biolysis rates were insensitive to substituent effects.

Correlation of -log $k_{biolysis}$ versus van der Waal's radii, γ_{vdw}, of individual substituents yielded correlation coefficients (r^2) of 0.7822, 0.9049, 0.7879 and 0.7875 for Arthrobacter (CSMNS), Arthrobacter (DSMP), Pseudomonas (CCS) and Bacillus (B.EPA), respectively. Substituent size and shape, rather than any electronic properties, apparently influence enzyme activity in this biolysis process. The similar dependence of biolysis rates on van der Waal's radii of the substituents for all genera of bacteria studied suggests that the same hydrolase enzyme is operative in each case.

The lack of correlation of alkaline hydrolysis and bacterial biolysis second-order rate constants indicates that the kinetics of these two processes are not controlled by the same substituent parameters.

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INTRODUCTION

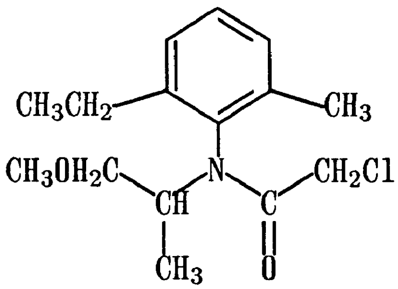
Statement of the Problem

Acetanilide is the organic base molecule employed in the synthesis and manufacture of a suite of herbicides, fungicides and plant growth regulators. Examples include alachlor (Lasso, Monsanto), metolachlor (Dual, Ciba-Geigy), propanil (Rogue, Monsanto) and propachlor (Ramrod, Monsanto) as herbicides; metalaxyl (Ridomil, Ciba-Geigy) as a fungicide; and mefluidide (Embark, 3M) as a plant growth regulator (Hartley and Kidd, 1983). Molecular structures of these representative acetanilide pesticides are illustrated in Figure 1.

Substitution of different atoms or groups of atoms in various positions on the molecule gives selective herbicidal properties to these compounds (Buchman and Hamilton, 1981). McClure (1974) showed that microbial hydrolysis is the primary degradation pathway of acetanilide herbicides in natural ecosystems.

However, substituent effects on the abiotic and biotic hydrolysis of para-substituted acetanilides are not well understood. Physico-chemical parameters controlling both the kinetics and mechanisms of hydrolysis need to be more clearly defined. By correlating molecular structure with reactivity, a more complete understanding of reaction processes involved in the hydrolysis of these acetanilide compounds can be attained.

Hence, the primary goal of this investigation is to determine specific substituent effects on the hydrolysis rates of para-substituted acetanilides. The scope of this study is limited to abiotic hydrolysis under alkaline conditions and biotic hydrolysis (biolysis) using pure cultures of aerobic



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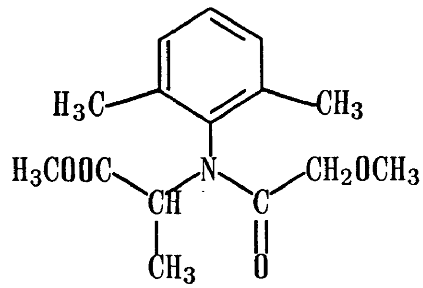

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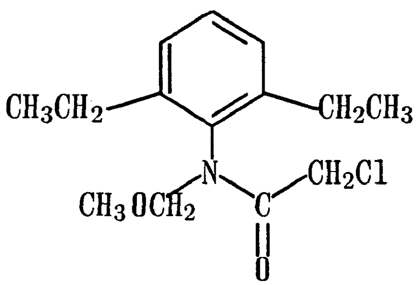

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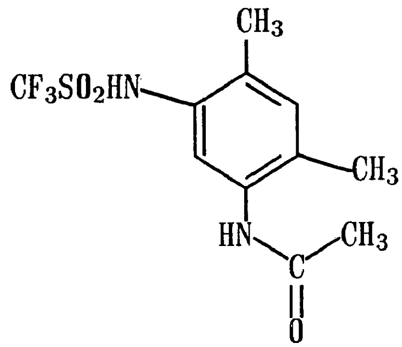

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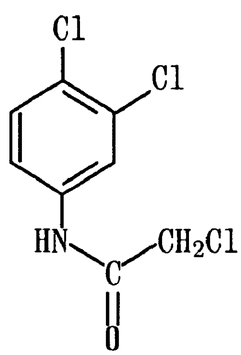

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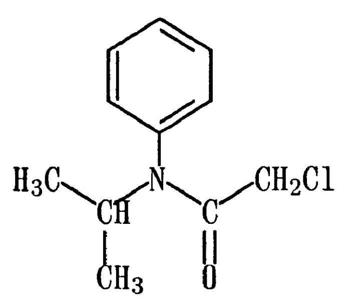

PROPACHLOR

Figure 1. Molecular structures of representative acetanilide pesticides.

bacteria. Results provide insight into mechanisms of, and substituent effects on the hydrolysis of para-substituted acetanilides.

Research Objectives

There were three fundamental objectives of this study. The first objective was to determine the substituent effects on the alkaline hydrolysis rates of a series of para-substituted acetanilides by measuring and investigating correlations of second-order rate constants to electronic parameters (e.g. Hammett sigma values) of individual substituents.

The second objective was to evaluate substituent effects on the biolysis of the same series of para-substituted acetanilides using pure cultures of bacteria. By measuring and investigating correlations of second-order rate constants to various physico-chemical substituent constants, substituent effects on biolysis rates and mechanisms of enzyme activity could be assessed.

A third objective involved comparing second-order rate constants from the alkaline hydrolysis and bacterial biolysis experiments to test the hypothesis that similar processes are operative in controlling the rates of biotic and alkaline abiotic hydrolysis of para-substituted acetanilides.

Literature Review

Structure-activity relationships. The utility of correlation analysis has long been demonstrated in physical organic chemisty (Chapman and Shorter, 1972; Shorter, 1973; Hine, 1975; Shorter, 1982; Wells, 1986; Exner, 1988), medicinal chemistry and pharmaceuticals (Leo, Hansch and Elkins, 1971; Hansch and Leo,

1979) and environmental chemistry (Lyman, Reehl and Rosenblatt, 1982) in predicting how fundamental physico-chemical parameters of molecular structure control specific reactions. Empirical correlations of the reactivities of organic compounds are usually expressed as linear relationships involving logarithms of rate (k) or of equilibrium (K) constants and some physical or chemical property of the molecules. Such correlations are described as either equilibrium-equilibrium, equilibrium-rate or rate-rate relations and are termed linear free energy relations (LFER's).

Hammett (1937) empirically derived a LFER correlating the alkaline hydrolysis rates of a series of substituted ethyl benzoates with their corresponding acid dissociation constants, generating equation (1).

$$m \log K/K_o = \log k/k_o \tag{1}$$

where m = the slope of the line. The terms K_o and k_o are equilibrium and rate constants for the unsubstituted ethyl benzoate, respectively. Substituting for K and k with the appropriate free energy (ΔG) and free energy of acitvation ($\Delta G^{\ddagger}$) results in equation (2).

$$m\ \Delta(\Delta G) = \Delta(\Delta G^{\ddagger}) \tag{2}$$

The linear correlation therefore indicates that the change in free energy of activation on introduction of a series of substituent groups or atoms is directly proportional to the change in free energy of ionization brought about by introduction of the same series of substituents on benzoic acid.

The Hammett Free-Energy relationship (Hammett, 1938) is expressed as follows, with equations (3) and (4) for equilibrium (e) and rate (r) data shown, respectively.

$$\log K/K_o = \sigma \rho_e \tag{3}$$

$$\log k/k_o = \sigma \rho_r \tag{4}$$

The numerical values of the terms σ and ρ were derived from the reference reaction, i.e. the ionization of substituted benzoic acids, whereby σ is a constant for each individual substituent effect and ρ is a constant = 1 for this reaction. Plotting log k/k_o versus σ gives a line of slope = ρ. Substituent constants, σ, were then determined for a series of substituents by measurement of the acid dissociation constants of the substitued benzoic acids. The σ values so experimentally defined are used in the correlation of other reaction series, and the ρ values are determined. Thus, ρ is a direct measure of the influence substituents exert on a particular reaction. A large ρ reflects high sensitivity to substituent effects, i.e. a large charge redistribution in the transition state. Also, the value of σ reflects the relative effect a particular substituent has on electron density. Positive σ values denote electron-withdrawing substituents, while negative σ values are electron-donating to the reaction center (Jaffe, 1953).

In assessing the influence of any substituent effect on a reaction, one must consider the interactions in reactant and transition states for rate processes. The Hammond Postulate says that if two states, as for example a transition state and an unstable intermediate, occur consecutively during a reaction process and have nearly the same energy content, their interconversion will involve only a small reorganization of molecular structure (Hammond, 1955). Therefore, substituent effects on rates must be assessed in terms of stabilization of that species which is the best model for the rate-determining transition state, whether reactant, product, or intermediate.

Effects of substituents on chemical reactivity can be divided into categories based on electronic and steric parameters. The polar effect of a substituent comprises all the processes whereby the substituent may influence the electron distribution at a reaction center, relative to a standard substituent, usually a hydrogen atom. Electrostatic forces operating at the reaction center are governed by complete electron distribution throughout the molecule and are modified by introduction of substituents. Inductive effects occur through polarization involving σ electrons. Field effects are direct, through-space electrostatic forces resulting from bond-dipole interactions. These generally outweigh inductive effects, and have been separated for purposes of correlation analysis (Taft, 1956).

The term resonance effect is applied to conjugative substituents involving π electron delocalization. For the aromatic compounds studied here, polarization of charge density around the ring through the π system in both reactant and transition states creates resonance effects in such conjugative substituents as nitro (NO_2) and cyano (CN). Substituents attached at the para position on the ring usually have the greatest resonance effects; therefore, para-substituted compounds are commonly used in LFER's to avoid unsymmetric electronic perturbations with the reaction center and steric hindrance effects (Chapman and Shorter, 1978).

Steric effects are caused by repulsive forces operating when two non-bonded atoms approach each other so closely that non-bonded compressions are involved. Taft (1952,1956) correlated the acid hydrolysis of a reaction series of esters with a steric constant defined as E_s. Results show that the actual size of the substituent atom or group will affect attainment of the transition state and thus affect reaction rate. Charton (1969) later found that the Taft E_s values are linearly related to the corresponding van der Waal's radii of the substituents.

Hammett (1936) showed that for many reaction series, ρ values decrease with increasing temperature, i.e. ρ varies as 1/T. Sigma values, by definition, are temperature independent.

Correlation coefficients, r or r^2, and the standard deviation, s, of values of log k or log K plotted against some substituent constant describe the linearity of the free-energy relationship (Shorter, 1973; Kleinbaum and Kupper, 1978).

Abiotic Hydrolysis of Para-Substituted Acetanilides

The hydrolysis rates of many organic compounds have been shown to be first order in substrate and to depend upon pH according to equation (5).

$$k_{hydrolysis\ (h)} = k_{observed} = k_B\ [OH^-] + k_A\ [H^+] + k_N \tag{5}$$

At any fixed pH, the overall rate process is pseudo first-order, and the half-life of the substrate is independent of its concentration (Mabey and Mill,1978). A half-life for the disappearance of the reactant molecule is calculated from equation (6).

$$t_{1/2} = (\ln 2)/k_h \quad (6)$$

Hence, second-order hydrolysis rate constants, k_A and k_B, may be derived from equations (7) and (8), respectively, under predominantly acid or alkaline conditions, and assuming neutral hydrolysis is so slow to be negligible.

$$k_A = k_h/[H^+] \quad (7)$$

$$k_B = k_h/[OH^-] \quad (8)$$

Acid hydrolysis. A Hammett LFER has been established for the acid-catalyzed hydrolysis of substituted acetanilides (Barnett and O'Connor, 1972,1973). Giffney and O'Connor (1975) measured the rates of hydrolysis of para-substituted acetanilides in varying concentrations of sulfuric acid (0.55-18.3 molar) at 100.1°C. Correlations with Hammett σ values for 12 substituents at the various sulfuric acid concentrations gave correlation coefficients (r) > 0.99. Reaction constants, ρ values, of 4.39 to 5.08 indicate that the reaction is strongly substituent dependent and favored by electron-withdrawing groups.

Alkaline hydrolysis. Bender and Thomas (1961) measured hydrolysis rate constants for acetanilide, p-chloroacetanilide, p-methylacetanilide and p-methoxyacetanilide in 0.239 and 0.957 molar hydroxide ion solutions. A ρ value of 0.1 was reported indicating that alkaline hydrolysis for this series of substituted acetanilides is insensitive to substituent effects. A general reaction mechanism for the alkaline hydrolysis of para-substituted acetanilides is represented in Figure 2, whereby the symbol, X, denotes a substituent in the para position. Plotting log k_B versus Hammett σ values gives a correlation coefficient (r^2) of 0.5268. The poor fit may simply be a result of such a small slope ($\rho = 0.1$).

Pollack and Bender (1970) reported a measured rate constant for the hydrolysis of p-nitroacetanilide in 0.24 molar hydroxide ion solution of 3.2 x 10^{-4} sec^{-1}. Using $\rho = 0.1$ and a value of σ^- for p-NO_2 of 1.27 (Leffler and Grunwald, 1963), the rate for para-nitroacetanilide is over 100 times faster than predicted on the basis of previous work. The researchers concluded that a reaction higher-order in hydroxide ion was responsible for the enhanced rate of alkaline hydrolysis of p-nitroacetanilide. Plotting log $k_{observed}$ versus log [OH-] over a hydroxide concentration of 9.59 x 10^{-3} - 9.59 x 10^{-1} M. gave a line of slope = 1.24. In addition, Erickson (1969) showed deviation from linearity (concave upward) in a pH-rate profile of log $k_{observed}$ for acetanilide hydrolysis versus log [OH^-]. Such non-linearity suggests a higher-order rate dependence in hydroxide ion at elevated pH's (> 0.1 molar hydroxide ion).

Bacterial Biolysis

Several processes influence biological transformations of organic compounds in the natural environment (Baughman and Burns, 1980). Hence, an understanding of fundamental reactions is necessary to accurately assess the importance of each process in controlling the overall environmental fate of certain chemicals. The role of microbial hydrolysis has been determined to be a major one; however, the mechanisms of, and factors controlling enzyme-mediated microbial hydrolysis

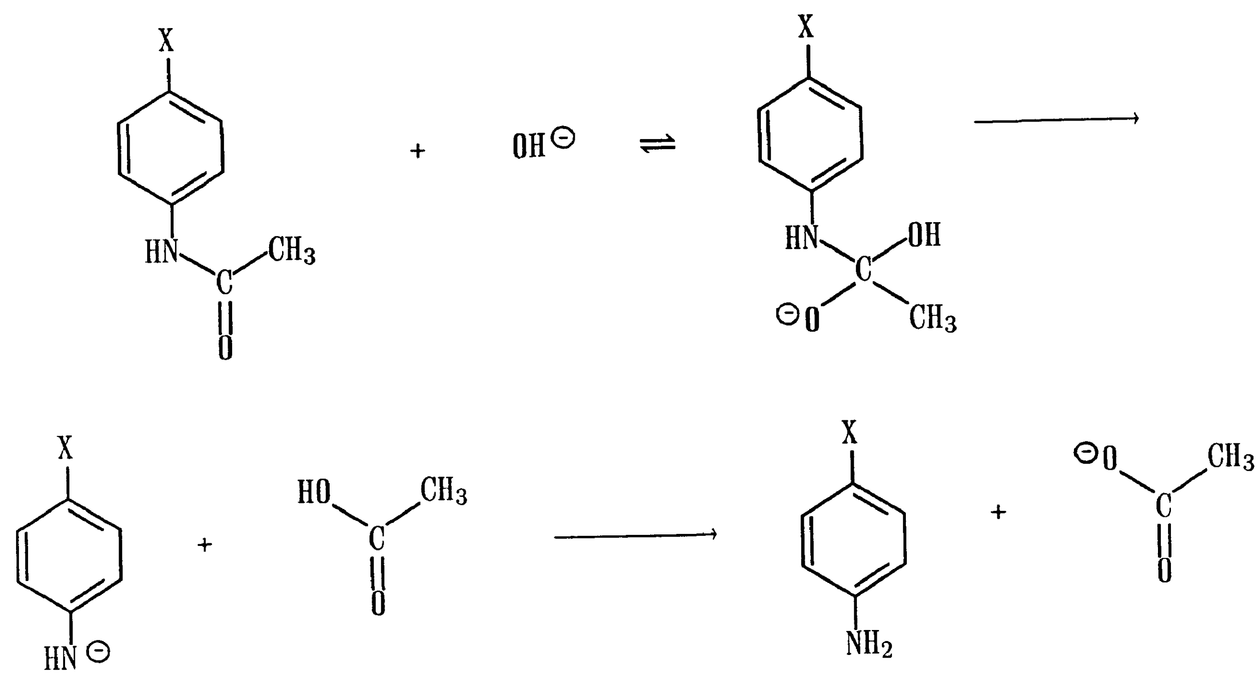

Figure 2. Reaction mechanism for the alkaline hydrolysis of para-substituted acetanilides.

Adapted from March, J., 1985. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. Wiley-InterScience, N.Y., p. 339.

of organic compounds are not fully understood (Kaufman and Kearney, 1976).

Enzyme kinetics and cell activity. Mathematical relationships have been developed to describe the growth of bacterial cells (Powell, 1956; Brock, Smith and Madigan, 1984). During the exponential growth phase of a single, pure bacterial culture, growth rate as a function of concentration of a single, limiting carbon source, S, is expressed in equation (9) derived by Monod (1949).

$$d[B]/dt = \mu = \mu_m [S] [B]/K_s + [S] \tag{9}$$

where $d[B]/dt = \mu$ = rate of bacterial population growth; μ_m = maximum rate of population growth; [S] = concentration of the growth-rate-limiting substrate; and K_s = substrate concentration at which $\mu = \mu_m/2$.

An analogous equation derived for application to enzyme kinetics is the Michaelis-Menten equation (Michaelis and Menten, 1913; Piszkiewicz, 1977). Evaluation of the constants, μ_m and K_s, is performed by linear regression based on equation (10).

$$[S]/\mu = ([S] + K_s)/\mu_m \tag{10}$$

A plot of $[S]/\mu$ versus [S] is linear, with slope μ_m and intercept K_s. A modification of the Monod equation represents metabolism of a single organic carbon source in a pure bacterial culture as illustrated in the empirical rate law of equation (11) (Paris, Lewis and Wolfe, 1975; Paris, Steen and Burns, 1982; Banerjee, 1984).

$$-d[S]/dt = \mu = \mu_m [S] [B]/ Y(K_s + [S]) \tag{11}$$

where $-d[S]/dt = \mu$ = rate of metabolism of the organic substrate, S; μ_m = maximum rate of metabolism of the substrate; [S] = concentration of the substrate; [B] = bacterial cell concentration or density; Y = yield factor, i.e. the efficiency with which substrate is converted to biomass; and Ks = substrate concentration at one-half the specific growth rate, μ_m. Mateles and Chain (1969) observed that K_s typically ranges from 0.1 to 10 milligrams/liter for organic substrates of interest. Under these conditions of a single, limiting carbon source, Y must approach 0 as [S] approaches 0 (Baughman, Paris and Steen, 1980). When [S] << K_s, equation (11) reduces to equation (12), which is in the familiar form for second-order kinetics.

$$-d[S]/dt = (\mu_m/Y\ K_s)\ [B]\ [S] = k\ [B]\ [S] \qquad (12)$$

where k is the second-order rate constant for bacterial metabolism of the substrate. Equivalence of $\mu_m/Y\ K_s$ and k has been demonstrated experimentally for systems where the substrate was the sole carbon source and second-order kinetics were observed (Paris et al., 1975).

The second-order rate law given by equation (12) can be verified by holding one concentration term constant while varying the other and observing the rate. Under these conditions, observed kinetics will be pseudo first-order and obey the rate law shown in equation (13).

$$-d[S]/dt = \mu = k_{obs.}\ [S] \qquad (13)$$

where $k_{obs.}$ equals k [B] with constant bacterial population. A linear plot of log [S] versus time verifies that the rate of substrate degradation is first-order in substrate. Likewise, it can be shown that rate of substrate degradation is first-order with respect to bacterial concentration. Taken together, such results verify the second-order rate law. Equation (12) has been successfully applied to model microbial transformations of organic chemicals in natural aquatic systems (Wolfe, Burns and Steen, 1980; Paris et al., 1981; Lewis, Holm and Hodson, 1984).

Structure-activity relationships. As early as 1961, researchers have related microbial pesticide transformations in the natural environment to chemical structure (Alexander and Aleem, 1961). Linear free energy relationships have been generated using rate data for reactions of organophosphate and organophosphorothioate esters (Wolfe, 1980), phthalate esters (Wolfe, Steen and Burns, 1980), carbamate pesticides (Wolfe, Zepp and Paris, 1978) and carboxylic acid esters (Paris, Wolfe and Steen, 1984). These relationships can be used to predict the environmental fate of structurally related organic compounds. Reactions and processes studied included hydrolysis, biolysis, sediment-water partition coefficients and biosorption. Wolfe et al. (1980) also demonstrated a correlation of log k_b for the oxidation of substituted phenols with Hammett σ values.

Paris, Wolfe and Steen (1982) and Paris et al. (1983) measured the effect of phenol molecular structure on bacterial transformation rate constants using a pure culture of Pseudomonas putida U., and pond and river samples, respectively. In both cases, a good correlation was obtained plotting log of the second-order bacterial oxidation rate constants versus van der Waal's radii of the substituents for a series of para-substituted phenols. Apparently, size of the substituent atom or group strongly influences the ability of an active enzyme or enzyme system to catalyze the oxidation of phenols. Similar conclusions were reached in the investigation of meta-substituted anilines. A pure culture isolated from river water and a pond water sample transformed the anilines to their corresponding oxidative deamination products. Simple linear regression of van der Waal's radii with log k_b gave correlation coefficients (r^2) of 0.924 for the river isolate and 0.99 for mixed populations (Paris and Wolfe, 1987). The length of lag phase in microbial oxidation of para-cyanophenol increased with increasing concentrations of substrate. In these experiments, para-cyanophenol was present as the sole source of organic carbon. These results are inconsistent with the work of Paris and Rogers (1986) who concluded that a limited organic nutrient supply was responsible for observed lag phases in microbial transformations of selected pesticides. Likewise, Wiggins, Jones and Alexander (1987) proposed limited inorganic nutrient supply to explain lag phases observed in the minerilization of selected organic compounds in lake water and sewage. Apparently, cell metabolism, and thus enzyme activity is limited by nutrient supply. The phenomenon of lag phases in microbial metabolism has been shown, in some cases, to be due to the time required for bacteria to synthesize an adaptive enzyme in response to the presence of substrate (Stanier et al., 1976).

Rate constants for microbial transformations often correlate with abiotic hydrolysis rate constants, suggesting that many biodegradation reactions are enzyme-mediated hydrolyses controlled by similar molecular parameters (Wolfe, Burns and Steen, 1980). Certainly, microbial transformations of organic chemicals are important in the environment and often control the fate of such compounds due to enhanced rates over abiotic processes.

Acetanilide-utilizing bacteria. Alt, Krisch and Hirsch (1975) isolated bacteria of the species Pseudomonas acidovorans AE1 capable of utilizing acetanilide as a sole source of carbon and energy. It was determined that hydrolysis was the primary metabolic reaction. Subsequent characterization of the hydrolase enzyme revealed it to be a single polypeptide of 58,000 molecular weight containing one active site per molecule (Alt, Heyman and Krisch, 1975). Utilization of aniline by other bacterial populations has also been reported (Walker and Harris, 1969; Cerniglia, Freeman and Baalen, 1981; Lyons, Katz and Bartha, 1984; Zeyer, Wasserfallen and Timmis, 1985).

Recently, Steen and Collette (1989) reported a correlation of the microbial transformation rate constants of seven amide herbicides and fungicides in natural pond water with the infrared carbonyl-stretching frequency of each compound. A correlation coefficient (r^2) = 0.962 suggested that the infrared carbonyl-stretching frequency may be used to predict microbial transformation rate constants of structurally related organic compounds in natural aquatic systems.

Much research has been performed investigating fundamental relationships of molecular structure with reactivity using many different organic compounds under various reaction conditions, both abiotic and biotic. This research focused on investigating structure-activity relationships of a particular series of seven para-substituted acetanilides under specific reaction conditions, i.e. alkaline hydrolysis and bacterial biolysis. Four of the seven compounds have been previously investigated under alkaline hydrolysis conditions, but none of the seven has been studied under biotic conditions.

EXPERIMENTAL METHODOLOGY AND DESIGN

Chemicals and Reagents

All para-substituted acetanilides, purchased as commercially synthesized compounds, were used as received. Purities were > 97 percent. Melting point determinations confirmed compound identity and purity. Acetanilide, para-bromoacetanilide, para-fluoroacetanilide, para-methoxyacetanilide, para-methylacetanilide (all from Lancaster Synthesis, LTD.), para-nitroacetanilide (Eastman Kodak Co.) and para-cyanoacetanilide (Pfaltz and Bauer, Inc.) comprised the series of compounds of which rate constants for alkaline hydrolysis and bacterial biolysis were measured (see Figure 3). Para-chloroacetanilide (Lancaster Synthesis, LTD.) and para-methylacetanilide were employed throughout the investigation as external standards for gas chromatographic (GC) analysis.

Corresponding para-substituted anilines, purchased as commercially synthesized compounds,were used as received and included aniline (Baker Analytical, Inc.), para-methylaniline, para-bromoaniline, para-nitroaniline (Eastman Kodak Co.), para-fluoroaniline, para-methoxyaniline and para-cyanoaniline (Aldrich Chemical Co.). Purities were > 98 percent. The anilines were used as calibration standards for hydrolysis product analyses to confirm product identity and concentrations in the kinetic studies.

Sodium hydroxide (Fischer Scientific Co., analytical grade) was used for the specific base-catalyzed hydrolyses of the acetanilides. Sodium hydroxide solutions were standardized with potassium hydrogen phthalate (Mallinckrodt, A.C.S. grade), which was dried for 6 hours at 140°C before use.

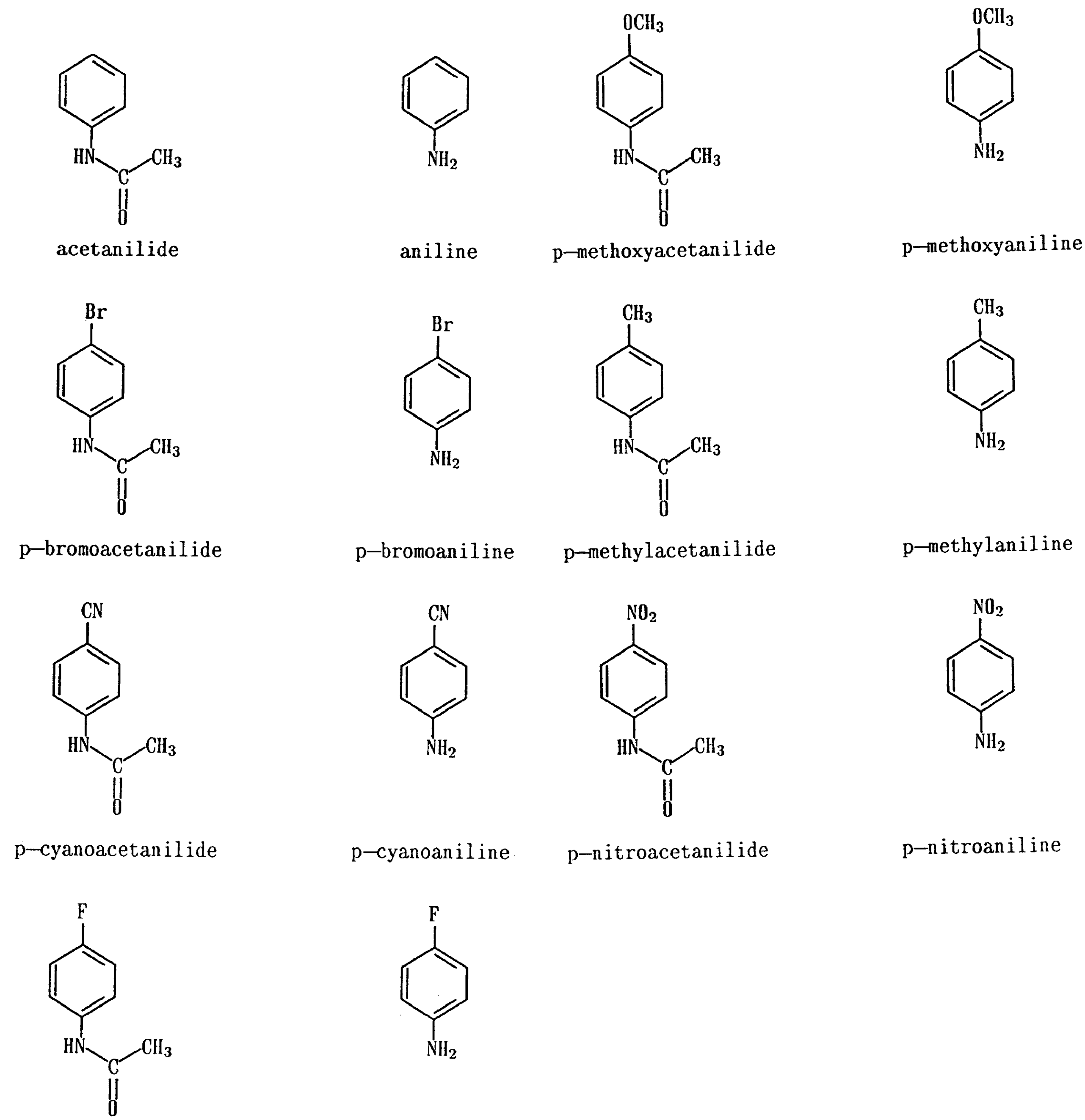

Figure 3. Molecular structures of selected para-substituted acetanilides and their corresponding aniline hydrolysis products.

Methylisobutylketone (MIBK, Eastman Kodak Co.), redistilled in glass, was used for solvent extractions of all para-substituted acetanilides and corresponding aniline hydrolysis products for GC analysis.

Inorganic salts, including K_2HPO_4, Na_2HPO_4, $MgSO_4 \cdot 7H_2O$, $FeSO_4 \cdot 7H_2O$, $CaCl_2$ and NH_4Cl, were commercial products used as received.

All water used to prepare aqueous solutions was deionized, filtered through a 0.45 micrometer permeable membrane (Nucleopore Corp.), and then autoclaved for 20 minutes at 121°C (250°F) in a MarketForge-Sterilmatic autoclave.

Glassware used throughout this study was cleaned by first washing in Micro detergent (International Products Corp.), rinsing with ten volumes of deionized water and then baking at 500°C for 6 hours.

Analytical Instrumentation and Procedures

Gas chromatographic analysis. A Hewlett-Packard (HP) 5890A gas chromatograph, equipped with a nitrogen-phosphorous detector (NPD), was employed for the analysis of the series of para-substituted acetanilides and their corresponding aniline hydrolysis products. A 25 meter, 5 % phenylmethyl silicone, megabore capillary column (HP) separated products and reactants. Signal output from the NPD was received by an HP 3392A integrator. Integrated peak areas, relative to an external standard, were used to calculate compound concentrations. For reactant and product identification and confirmation, retention times relative to para-substituted acetanilide and aniline standards were compared using the same GC system (see Table 1).

Aliquots of 1.0 microliter (uL.) volume were injected for GC analysis using a

Table 1. Gas chromatographic (GC) retention times for para-substituted acetanilides and corresponding anilines.

Compound	Retention Time (minutes)	Compound	Retention Time (minutes)
Temperature Program 1 = para-chloroacetanilide as external standard.			
Acetanilide	3.80	aniline	1.48
para-fluoro-acetanilide	3.84	para-fluoro-aniline	1.70
para-methyl-acetanilide	4.34	para-methyl-aniline	2.13
para-chloro-acetanilide	4.84		
para-methoxy-acetanilide	5.15	para-methoxy-aniline	3.00
para-bromo-acetanilide	5.30	para-bromo-aniline	3.46
para-cyano-acetanilide	5.64	para-cyano-aniline	4.20
Temperature Program 2 = para-methylacetanilide as external standard.			
para-nitro-acetanilide	4.65	para-nitro-aniline	3.16
para-methyl-acetanilide	2.45		

10.0 uL. Model 1701 GC syringe (Hamilton Co.). Two injections per sample were analyzed to determine instrument precision. Cleaning of the injection syringe between GC runs entailed wiping tip and plunger with methanol and drawing acetone, isooctane, hexane, methanol and MIBK through the syringe body, each for 10 seconds by suction via vacuum take-off.

Temperature Programs. Gas chromatographic conditions for the analysis of all para-subsituted acetanilides and anilines were as follows: detector temperature - 300°C, injection port temperature - 300°C, NPD bead power range 500-800 to give a 10.0 - 15.0 millivolt baseline, and carrier gas (00-grade air) and make-up gas (helium) flow rate - 5.0 milliliters/minute (mL./min.).

Two temperature programs were developed to yield the most efficient chromatography, as properties of the seven para-substituted acetanilides and anilines differed markedly. For the analysis of acetanilide, para-bromoacetanilide, para-fluoroacetanilide, para-methoxyacetanilide, para-methylacetanilide,para-cyanoacetanilide and their corresponding para-substituted aniline hydrolysis products, initial oven temperature was set at 100°C , final temperature at 250°C. A holding time of 1.0 min. and a rate thereafter of 25°C/min. gave an analysis run time of 7.0 min.. Para-chloroacetanilide was the external standard. For the analysis of para-nitroacetanilide and para-nitroaniline, initial temperature was set at 150°C with a final temperature of 250°C. A holding time of 1.0 min. and rate of 20°C/min. gave an analysis run time of 6.0 min. Para-methylacetanilide was used as the external standard.

Extraction of acetanilides and anilines. MIBK was selected for solvent extraction of the para-substituted acetanilides and product anilines from aqueous solution due to its low water solubility (Munro, 1968). Also, the low density of MIBK facilitated phase separation and sample removal. Detector response to MIBK in GC-NPD analysis was negligible. Extraction efficiencies into MIBK were > 94 percent for all seven para-substituted acetanilides over a concentration range of 10^{-5}-10^{-4} moles/liter. Average extraction efficiencies with corresponding standard deviations are listed in Table 2. Calculations to determine concentrations of compounds were performed assuming 100 % extraction efficiency for both reactants and products in all cases.

Calibration standards. Para-substituted acetanilide and aniline standards were prepared in MIBK over a concentration range of 10^{-5}-10^{-4} Molar. Upon GC analysis, integrated detector response gave peak area ratios which were correlated to concentrations using simple linear regression. Based on these calibration curves, concentrations were calculated to generate rate data. Tables 3 and 4 show data for calibration standards of the para-substituted acetanilides and anilines, respectively.

Alkaline Hydrolysis

Solution preparation. All aqueous solutions of para-substituted acetanilides were prepared at 2.0 x 10^{-4} moles/liter and stored in 1.0 liter (L.) glass-stoppered volumetric flasks in the absence of light at ambient temperature. The external standards, para-chloroacetanilide and para-methylacetanilide, were prepared in distilled MIBK at concentrations of 1.2 x 10^{-4} moles/L. and stored in Teflon-lined screw cap, 1.0 L. amber-glass bottles at ambient temperature.

Table 2. Average extraction efficiencies of para-substituted acetanilides into MIBK from deionized water.

Compound	Extraction Efficiency (%), n=8
Acetanilide	99.0 ± 4.1
para-fluoro-acetanilide	98.6 ± 5.1
para-methyl-acetanilide	98.4 ± 1.1
para-methoxy-acetanilide	97.9 ± 1.5
para-bromo-acetanilide	92.5 ± 5.4
para-cyano-acetanilide	102.3 ± 8.0
para-nitro-acetanilide	102.4 ±12.9

Table 3. Calibration standards for gas chromatographic detector response of para-substituted acetanilides.

			Linear Regression Analysis	
Compound	Concentration (10E+04 Molar)	Detector Response (Peak Area Ratio)	Y Intercept, b Slope, m	Correlation Coefficient, r^2
Acetanilide	0.1	0.17078	-1.533E-06	0.9981
	0.2	0.34915	6.099E-05	
	0.5	0.88737		
	1.0	1.64469		
para-fluoro-acetanilide	0.1	0.21647	-4.182E-06	0.9938
	0.2	0.41475	5.715E-05	
	0.5	1.02905		
	1.0	1.78182		
para-methyl-acetanilide	0.1	0.20867	-1.542E-06	0.9991
	0.2	0.41482	5.158E-05	
	0.5	1.03276		
	1.0	1.95336		

(continued)

Table 3. (continued)

			Linear Regression Analysis	
Compound	Concentration (10E+04 Molar)	Detector Response (Peak Area Ratio)	Y Intercept, b Slope, m	Correlation Coefficient, r^2
para-methoxy-acetanilide	0.1	0.18373	-3.889E-07	0.9997
	0.2	0.37676	5.394E-05	
	0.5	0.95247		
	1.0	1.85263		
para-bromo-acetanilide	0.1	0.19081	-6.628E-06	0.9930
	0.2	0.41332	6.932E-05	
	0.5	0.86943		
	1.0	1.50607		
para-cyano-acetanilide	0.1	0.27418	-1.568E-06	0.9991
	0.2	0.61859	3.679E-05	
	0.5	1.42464		
	1.0	2.74527		
para-nitro-acetanilide	0.1	0.13020	-1.552E-06	0.9993
	0.2	0.24812	8.520E-05	
	0.5	0.62328		
	1.0	1.31648		

Table 4. Calibration standards for gas chromatographic detector response of para-substituted anilines.

			Linear Regression Analysis	
Compound	Concentration (10E+04 Molar)	Detector Response (Peak Area Ratio)	Y Intercept, b Slope, m	Correlation Coefficient, r^2
Aniline	0.1	0.1713	-7.924E-07	0.9992
	0.2	0.2812	6.866E-05	
	0.5	0.7500		
	1.0	1.4652		
para-fluoro-aniline	0.1	0.1440	-3.255E-07	0.9992
	0.2	0.2515	7.252E-05	
	0.5	0.6986		
	1.0	1.3700		
para-methyl-aniline	0.1	0.1754	-6.149E-07	0.9990
	0.2	0.2919	6.042E-05	
	0.5	0.8292		
	1.0	1.6419		

(continued)

Table 4. (continued)

			Linear Regression Analysis	
Compound	Concentration (10E+04 Molar)	Detector Response (Peak Area Ratio)	Y Intercept, b Slope, m	Correlation Coefficient, r^2
para-methoxy-aniline	0.1	0.2121	-3.713E-06	0.9996
	0.2	0.3455	6.594E-05	
	0.5	0.8303		
	1.0	1.5670		
para-bromo-aniline	0.1	0.2454	-6.421E-07	0.9992
	0.2	0.4266	4.535E-05	
	0.5	1.1450		
	1.0	2.2092		
para-cyano-aniline	0.1	0.5120	-1.662E-06	0.9976
	0.2	0.9300	2.199E-05	
	0.5	2.4815		
	1.0	4.5650		
para-nitro-aniline	0.1	0.2721	-3.255E-06	0.9976
	0.2	0.4316	4.967E-05	
	0.5	1.1262		
	1.0	2.0564		

Sodium hydroxide solutions prepared at 2.00 x 10^{-1} moles/L. by dissolving NaOH pellets in deionized water were used for the specific base-catalyzed hydrolysis of all seven para-substituted acetanilides. Para-cyanoacetanilide was selected as a model compound for alkaline hydrolysis at hydroxide ion molarities of 0.1, 0.032 and 0.01 to test the occurence of a linear pH dependence over this range, i.e. kinetics first-order in hydroxide ion. Hence, NaOH solutions of 6.32 x 10^{-2} and 2.00 x 10^{-2} moles/L. sodium hydroxide were also prepared. Storage of all NaOH solutions in 1.0 L. glass-stoppered volumetric flasks decreased CO_2 absorption from the atmosphere.

No pH buffer was added to the reaction solutions to avoid general acid-base (buffer) catalytic effects on rate constants.

Determination of hydroxide ion concentration. Standardization of alkaline solutions was performed at the start of reactions and after generation of kinetic data (2 to 3 half-lives of hydrolysis) as determined by potassium hydrogen phthalate (KHP) titration using phenolphthalein as indicator.

Kinetic experiments. From a measured second-order rate constant for acetanilide of 7.55 x 10^{-6} seconds^{-1} L. mole^{-1} (Bender and Thomas, 1961), a calculated half-life of 10.6 days is obtained at 0.1 molar hydroxide ion concentration. Thus, hydrolysis reactions for para-bromo, para-fluoro, para-methoxy, para-methyl, para-cyano ([OH-] = 0.01 and 0.032 M.) and the unsubstituted acetanilide were run for 30 days to ensure at least 2 half-lives of hydrolysis for kinetic data. Sample aliquots were taken every two days.

Likewise, from a measured second-order rate constant for para-nitroacetanilide of 1.20 x 10^{-3} $seconds^{-1}$ L. $mole^{-1}$ (Pollack and Bender, 1970), a calculated half-life of 1.6 hours is obtained at 0.1 molar hydroxide ion concentration. Hence, the reaction was run for 5 hours taking samples every 30 minutes. For the measurement of kinetics for para-cyanoacetanilide at [OH-] = 0.1 M., based on rate data from the hydrolysis experiments at [OH-] = 0.032 and 0.01 M., and assuming a rate law first order in hydroxide ion, hydrolysis reactions were run over a six day period taking samples every 12 hours.

Alkaline hydrolysis experiments were conducted isothermally in a thermostated water bath at 25.0±0.2°C. Hydrolysis reactions were initiated by pipetting 100 mL. each of the para-substituted acetanilide and sodium hydroxide solutions into glass-stoppered, 250 mL. iodine flasks wrapped in aluminum foil to minimize photolytic effects. Thus, starting concentrations were 1.0 x 10^{-4} molar acetanilide and 0.100, 0.032 and 0.010 molar hydroxide ion, respectively. Reaction vessels were immediately placed into the water bath to equilibrate at a temperature of 25.0°C.

Two separate reaction flasks for each para-substituted acetanilide were run to determine precision of hydrolysis rate constants. Sample aliquots were taken at the prescribed intervals. All solution volume transfers were performed using glass pipettes. An 8.0 mL. sample of alkaline solution was pipetted into a glass-stoppered 20.0 mL. test tube, then 4.0 mL. of MIBK was added to extract the acetanilides and product anilines into the organic phase. Extraction was completed by handshaking the test tube for 1.0 min., and then vortexing for 2.0 min. on a vortex mixer (VWR Scientific Co.), speed - 8. In a clean test tube, 2.0 mL. of the extract was combined with 2.0 mL. external standard. A 1.0 uL. aliquot of this sample was then injected into the GC for analysis.

Sterility. After approximately two half-lives of hydrolysis, select samples from acetanilide and para-cyanoacetanilide alkaline solutions were innoculated on nutrient agar (Fischer Scientific Co.) and incubated in a LabLine Co. incubator at 30°C for 7 days. Plates showed no evidence of bacterial growth at these elevated pH's.

Bacterial Biolysis

Environmental sample collection. Samples were collected from areas in Golden, Colorado, including natural soil, a manure pile, highly fertilized lawn, garden soil and creek sediment and labelled according to locale (see Table 5).

Selective isolation of pure cultures. Culture tubes (30 mL. with vented plastic caps) containing 10.0 mL. 1.0 x 10^{-2} moles/L. acetanilide and 10.0 mL. inorganic salts medium were innoculated with 0.5 - 1.0 grams (g.) wet weight of soil or sediment sample. The inorganic salts medium was prepared by dissolving 1.0 g. K_2HPO_4, 1.0 g. NH_4Cl, 0.01 g. $MgSO_4 \cdot 7H_2O$, 0.01 g. $FeSO_4 \cdot 7H_2O$, and 0.01 g. $CaCl_2$ in 1.0 L. deionized water (Stanier et. al., 1976). Solution pH was 7.2.
Pure cultures of acetanilide-utilizing bacteria were selectively isolated by innoculating streak plates of purified agar (Fischer Scientific Co.), 1.0 x 10^{-2} Molar acetanilide and inorganic salts medium with a loopful of solution from the culture tube slurry. After 7 days incubation at 30°C, cultures were successively isolated until there was only one culture per plate distinguished by color and morphology of colonies (Gerhardt,1981). Four different pure cultures of bacteria demonstrated the ability to utilize acetanilide as a sole source of carbon and energy. Their ability to utilize the remaining para-substituted acetanilides as a sole source of carbon and

Table 5. Sampling locations and matrices for bacterial isolates used in biolysis experiments.

Sample Name	Sampling Location	Matrix
SCM	Student Center Mud	Sediment
MPPM	Mines Park Pond Mud	Sediment
CCS	Clear Creek Sediments	Sediment
CSMNS	CSM Natural Soil	Soil
CCTS	Clear Creek Tributary Sediments	Sediment
FSCS	Ford Street Creek Sediments	Sediment
JRG	Jim Ranville's Garden	Soil
IMF	Intramural Field	Soil
DSMP	Dan Schultz's Manure Pile	Soil
LPPS	Lion's Park Pond Sediment	Sediment
B.EPA	A Pure Culture of the Genus Bacillus donated by the U.S EPA - Environmental Research Laboratory, Athens, GA. - courtesy of Dr. N.L. Wolfe	Isolated Pure Culture
Note: All samples collected in Golden, Colorado, except B.EPA.		

energy was also demonstrated qualitatively as evidenced by turbid bacterial growth in culture tubes after 5 days of incubation.

Acetate utilization. An experiment was conducted using the isolated acetanilide-utilizing bacteria to determine their ability to utilize acetate (a hydrolysis product of acetanilide) as a sole source of carbon and energy. Culture tubes containing 10.0 mL. 1.0 x 10^{-4} molar $NaC_2H_3O_2 \cdot 3H_2O$ (sodium acetate) and 10.0 mL. inorganic salts medium were innoculated with the four pure culture isolates, and showed excellent growth after 3 days of incubation. Unbuffered acetanilide solutions dropped in pH from 7.2 to 5.0 due to increasing acetate concentrations with time. Hence, to maintain optimal bacterial metabolism during biolysis experiments, phosphate buffer was added to all reaction solutions, holding pH near neutrality. Phosphate buffer solutions were prepared as 0.025 molal by dissolving 3.53 g. Na_2HPO_4 and 3.39 g. KH_2PO_4 in 1.0 L. deionized water (Weast, 1967). Solution pH was 6.87.

Genus identification. Four different pure cultures of bacteria were identified to the genus level by employing various techniques including colony and cellular descriptions, microscopic characterization and Gram staining (Stanier, Palleroni and Doudoroff, 1966; Buchanan and Gibbons, 1974; Gerhardt, 1981; Stanier et al., 1981; Krieg and Holt, 1984).

Growth of batch cultures. Resting cell experiments, designed to minimize bacterial growth and maintain constant cell concentrations throughout the kinetic studies by limiting available nutrients for cell metabolism, were conducted using large populations of two strains of Arthrobacter (samples CSMNS and DSMP) and one Bacillus (sample B.EPA) and one Psuedomonas (sample CCS) strain. It was determined that a combination of equal volumes of nutrient broth (Oxoid Co.), phosphate buffer and 1.0 x 10^{-4} molar acetanilide solution yielded the best growth for all bacterial cultures.

Thus, sterilized media containing 200 mL. each of these solutions were innoculated with the four pure cultures and incubated 14 days. Batch cultures were concentrated by centrifugation at 14,000 revolutions per minute (rpm) for 15 min. at 5°C in a refrigerated centrifuge (International Equipment Co.). Cells were washed twice with phosphate buffer to remove excess nutrients, then suspended in phosphate buffer in a 20 mL. Teflon-lined screw cap test tube and refrigerated until used in kinetic biolysis studies.

Cell concentrations. Starting concentrations for all bacterial biolysis experiments were determined by direct microscopic counting using a Nikon type 104 phase contrast, polarized light microscope and a Neubauer-Helber counting chamber (Aloe Scientific, Inc.). Cell concentrations are reported in organisms/L.

For the genera Bacillus and Pseudomonas, direct microscopic counts were performed at intervals of 12.0 and 24.0 hours throughout the kinetic studies to determine changes in cell concentration and the extent of bacterial growth, if any, during biolysis of the series of para-substituted acetanilides. Plate counting on the two cultures of Arthrobacter (CSMNS and DSMP) at intervals of 0.0, 4.0 and 8.0 hours throughout the kinetic studies was employed due to cell concentrations too low for direct microscopic counting (Gerhardt, 1981). Cell concentrations are reported as colony forming units/liter (CFU/L.).

All counting was done on the unsubstituted acetanilide, as it was assumed that equal concentrations of cells were present in reaction vessels of the other para-substituted acetanilides through consistent dilution of the batch culture. Random checks on selected solutions of substituted acetanilides were in general agreement with reported cell concentrations.

Kinetic experiments. Bacterial biolysis experiments were conducted isothermally in a thermostated water bath at 30.0 ±0.2°C. Neutral pH was maintained in all reaction vessels by the addition of phosphate buffer solution. Trial kinetic experiments were run and bacterial cell concentrations were adjusted to yield half-lives on the order of 3-5 hours for the biolysis of acetanilide. Fifty milliliters (mL.) each of the para-substituted acetanilide and phosphate buffer solutions were combined in glass-stoppered 250 mL. iodine flasks wrapped in aluminum foil to minimize photolytic effects. Biolysis reactions were initiated by pipetting 1.0 mL. of the concentrated bacterial cell suspension into the reaction vessels which were then immediately placed into the water bath to equilibrate at a temperature of 30.0±0.2°C. Thus, starting concentrations were 1.0×10^{-4} molar acetanilide and 1/100 of the initial concentrated bacterial cell suspension.

Two separate reaction flasks for each para-substituted acetanilide were run to determine precision of biolysis rate constants. Sample aliquots were taken at 1.0 hour intervals, unless otherwise noted. All solution volume transfers were performed using glass pipettes that were heat sterilized at 150°C for 2 hours before use. A 4.0 mL. sample of reaction solution was pipetted into a glass-stoppered 20 mL. test tube, then 2.0 mL. of MIBK was added to extract the acetanilides and product anilines into the organic phase. Extraction was completed by votexing the sample 2.0 min. at speed 8 on the VWR vortex mixer. If an emulsion formed upon extraction with MIBK, as it did using the genera Bacillus (sample B. EPA) and Pseudomonas (sample CCS), sample test tubes were centrifuged for 10 min. at 3400 rpm in a Centrific Model 228 centrifuge (Fischer Scientific Co.). In a clean test tube, 1.0 mL. of the extract was combined with 1.0 mL. external standard. A 1.0 uL. aliquot of the sample was then injected into the GC for analysis.

RESULTS AND DISCUSSION

Alkaline Hydrolysis

Results of the kinetics for disappearance of reactant and appearance of product for alkaline hydrolysis of a series of seven para-substituted acetanilides have been compiled in Tables 6 and 7, respectively. Higher variance in kinetic data for appearance of para-substituted anilines was apparent when analyzing graphical representations of the data. Such variation was also reflected in statistical analysis and may be attributed to interactions of certain para-substituted anilines with an organic coating on the aluminum foil used to cap test tubes during extraction with MIBK. Some small extraneous peaks were detected chromatographically, but their identity was not determined. The problem was later rectified by using the uncoated side of the aluminum foil. Correlations with electronic parameters were attempted only using rate constants calculated from kinetic data for the disappearance of para-substituted acetanilides. Regressions of the natural logarithm of reactant concentration versus time were virtually linear, consistent with pseudo first-order kinetics. The observed rate constant, $k_{observed}$, is equal to the slope of the line (see Appendix).

In all but one instance (para-methylacetanilide), hydroxide ion concentrations decreased over time. These decreases in OH^- concentration could be due to reaction with the glass vessels. In the alkaline hydrolysis of p-methylacetanilide, no statistically significant change in OH^- concentration occurred. Values are listed in Table 8. Average hydroxide ion concentrations (initial and final) were used to calculate second-order hydrolysis rate constants.

Table 6. Summary of kinetic results for alkaline hydrolysis experiments (disappearance of reactant).

Compound/ Replicate		k observed (sec-1)	k hydrolysis (sec-1 M-1)	average k hydrolysis (sec-1 M-1)	-log average k hydrolysis
acetanilide	I	7.35 ±0.12 E-07	7.72 ±0.22 E-06	7.70 ±0.18 E-06	5.1135
	II	7.36 ±0.12 E-07	7.67 ±0.14 E-06		
para-bromo-	I	7.23 ±0.17 E-07	7.56 ±0.21 E-06	7.40 ±0.22 E-06	5.1308
acetanilide	II	6.91 ±0.15 E-07	7.24 ±0.22 E-06		
para-cyano-	I	3.44 ±0.24 E-06	3.58 ±0.25 E-05	3.77 ±0.23 E-05	4.4237
acetanilide	II	3.78 ±0.19 E-06	3.95 ±0.22 E-05		
([OH-] = 0.10 M)					
para-cyano-	I	1.14 ±0.08 E-06	3.88 ±0.39 E-05	3.88 ±0.33 E-05	4.4112
acetanilide	II	1.15 ±0.06 E-06	3.87 ±0.27 E-05		
([OH-] = 0.032 M)					
para-cyano-	I	2.88 ±0.32 E-07	3.18 ±0.60 E-05	3.00 ±0.58 E-05	4.5229
acetanilide	II	2.59 ±0.37 E-07	2.81 ±0.55 E-05		
([OH-] = 0.01 M)					
para-fluoro-	I	8.11 ±0.20 E-07	8.45 ±0.22 E-06	8.34 ±0.19 E-06	5.0788
acetanilide	II	7.88 ±0.14 E-07	8.22 ±0.16 E-06		
para-methoxy-	I	8.43 ±0.51 E-07	8.80 ±0.55 E-06	8.90 ±0.63 E-06	5.0506
acetanilide	II	8.63 ±0.67 E-07	9.00 ±0.71 E-06		
para-methyl-	I	6.92 ±0.05 E-07	7.21 ±0.06 E-06	7.25 ±0.08 E-06	5.1397
acetanilide	II	6.99 ±0.09 E-07	7.28 ±0.10 E-06		
para-nitro-	I	1.06 ±0.06 E-04	1.11 ±0.06 E-03	1.15 ±0.07 E-03	2.9393
acetanilide	II	1.14 ±0.07 E-04	1.19 ±0.07 E-03		

Table 7. Summary of kinetic results for alkaline hydrolysis experiments (appearance of product).

Compound/ Replicate		k observed (sec-1)	k hydrolysis (sec-1 M-1)	average k hydrolysis (sec-1 M-1)	-log average k hydrolysis
acetanilide	I	3.83 ± 0.22 E-07	4.02 ± 0.28 E-06	4.19 ± 0.28 E-06	5.3788
	II	4.17 ± 0.25 E-07	4.35 ± 0.27 E-06		
para-bromo-	I	1.03 ± 0.04 E-06	1.08 ± 0.05 E-05	1.05 ± 0.05 E-05	4.9788
acetanilide	II	9.65 ± 0.33 E-07	1.01 ± 0.04 E-05		
para-cyano-	I	4.69 ± 0.46 E-07	4.88 ± 0.48 E-06	4.87 ± 0.51 E-06	5.3125
acetanilide	II	4.66 ± 0.49 E-07	4.86 ± 0.53 E-06		
([OH-] = 0.10 M)					
para-cyano-	I	9.88 ± 1.50 E-08	3.36 ± 0.61 E-06	3.36 ± 0.58 E-06	5.4737
acetanilide	II	9.97 ± 1.43 E-08	3.36 ± 0.54 E-06		
([OH-] = 0.032 M)					
para-cyano-	I	5.05 ± 0.13 E-08	5.58 ± 0.58 E-06	5.53 ± 0.57 E-06	5.2573
acetanilide	II	5.04 ± 0.24 E-08	5.47 ± 0.56 E-06		
([OH-] = 0.01 M)					
para-fluoro-	I	8.86 ± 0.61 E-07	9.23 ± 0.65 E-06	1.13 ± 0.10 E-05	4.9469
acetanilide	II	1.28 ± 0.13 E-06	1.33 ± 0.14 E-05		
para-methoxy-	I	4.77 ± 1.55 E-07	4.98 ± 1.63 E-06	5.89 ± 1.51 E-06	5.2299
acetanilide	II	6.52 ± 1.32 E-07	6.80 ± 1.38 E-06		
para-methyl-	I	6.25 ± 0.62 E-07	6.51 ± 0.65 E-06	6.41 ± 0.59 E-06	5.1931
acetanilide	II	6.07 ± 0.50 E-07	6.32 ± 0.53 E-06		
para-nitro-	I	1.36 ± 0.07 E-04	1.42 ± 0.08 E-03	1.32 ± 0.07 E-03	2.8794
acetanilide	II	1.17 ± 0.05 E-04	1.22 ± 0.05 E-03		

Table 8. Hydroxide ion concentrations for alkaline hydrolysis experiments.

Compound	Replicate	Initial [OH-] (10E+02 Molar)	Final [OH-] (10E+02 Molar)	Average [OH-] (10E+02 Molar)
Acetanilide	I	9.61	9.43	9.52 ±0.12
	II	9.61	9.58	9.59 ±0.02
para-fluoro-acetanilide	I	9.61	9.60	9.60 ±.01
	II	9.61	9.58	9.59 ±.02
para-methyl-acetanilide	I	9.59	9.61	9.60 ±.01
	II	9.59	9.61	9.60 ±.01
para-methoxy-acetanilide	I	9.59	9.56	9.58 ±.02
	II	9.59	9.58	9.59 ±.01
para-bromo-acetanilide	I	9.59	9.53	9.56 ±.04
	II	9.59	9.49	9.54 ±.08
para-cyano-acetanilide	I	9.61	9.60	9.61 ±.01
	II	9.61	9.55	9.58 ±.04
para-cyano-acetanilide	I	3.01	2.88	2.94 ±.09
	II	3.01	2.94	2.97 ±.05
para-cyano-acetanilide	I	0.954	0.856	0.905 ±.07
	II	0.954	0.888	0.921 ±.05
para-nitro-acetanilide	I	9.60	9.57	9.58 ±.02
	II	9.60	9.58	9.59 ±.01

Close agreement between rate constants calculated from kinetic data for disappearance of reactant and appearance of product indicates that hydrolysis was the primary reaction of p-bromo-, p-fluoro-, p-methoxy-, p-methyl-, p-nitro-, and the unsubstituted acetanilide under alkaline conditions. All of the variance in kinetic data (both abiotic and biotic experiments) was not accounted for statistically. In cases where appearance of product rate constants are slightly greater than disappearance of reactant rate constants, variance may be attributed to differential adsorption of para-substituted acetanilides to glass surfaces of reaction vessels, and/or volatilization of para-substituted anilines from GC analysis test tubes. However, these processes were not investigated in this study.

An alkalinity-rate profile for p-cyanoacetanilide (Figure 4) over a hydroxide ion concentration range of 0.01 - 0.1 molar is linear (r^2 = 0.996), suggesting an overall rate law for the alkaline hydrolysis of para-substituted acetanilides first-order in hydroxide ion over this pH range.

For the compounds p-bromo-, p-fluoro-, p-methoxy-, p-methyl- and the unsubstituted acetanilide, second-order hydrolysis rate constants ranged from 7.25×10^{-6} to 8.90×10^{-6} sec^{-1} M^{-1}, showing very little substituent effect on the rate of hydrolysis at high pH. However, second-order hydrolysis rate constants of 3.77×10^{-5} sec^{-1} M^{-1} for p-cyanoacetanilide and 1.15×10^{-3} sec^{-1} M^{-1} for p-nitroacetanilide show large substituent effects on hydrolysis rates with these strongly electron-withdrawing substituents. Direct conjugation of electron-withdrawing substituents with the reaction center via resonance contributes to enhanced rates of hydrolysis. Larger sigma values, called σ_p^- (Yukawa and Tsuno, 1959), have been used to account for this difference. Substituent constant sigma values (both σ_p, and σ_p^- for

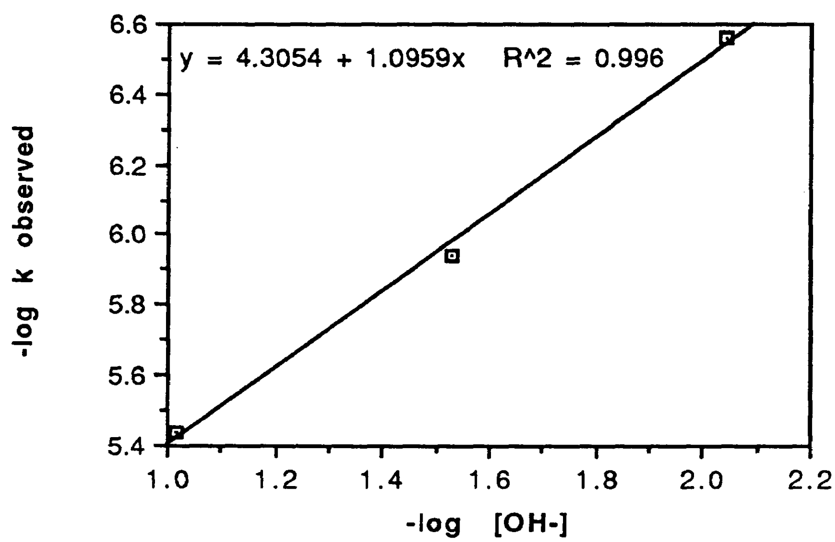

Figure 4. Rate-alkalinity profile for para-cyanoacetanilide.

CN and NO_2) were taken from Jaffe (1953) and are listed in Table 9. Correlation of the negative logarithm of second-order hydrolysis rate constants for individual para-substituted acetanilides with their corresponding Hammett electronic substituent constants, σ_p and σ_p^-, was not linear. In the cases of p-cyano- and p-nitroacetanilide, different mechanisms or competing reactions may account for their large hydrolysis rate constants.

Correlation of the negative logarithm of second-order hydrolysis rate constants for p-bromo-, p-fluoro-, p-methoxy-, p-methyl-, and the unsubstituted acetanilide with their corresponding Hammett electronic substituent constants, σ_p, gave poor linear regression (r^2 = 0.1883). The equation for the line is y = 0.0824 x + 5.1051 (see Figure 5). Such a low correlation coefficient may simply be a result of a small slope. The linear free energy relationship yielded a reaction constant, ρ, of 0.082, indicating that alkaline hydrolysis of this series of five para-substituted acetanilides is insensitive to substituent effects. These data support the conclusions of Bender and Thomas (1961).

Hydrolysis of nitrile compounds is well established in the chemical literature (March, 1985). For p-cyanoacetanilide, hydrolysis of the nitrile substituent by hydroxide ion may explain the observed larger rate constant for disappearance of reactant compared to the rate constant for appearance of the aniline product. There is approximately one order of magnitude difference between these rate constants. The competing reaction mechanism of nitrile hydrolysis is illustrated in Figure 6. Corresponding hydrolysis of the cyano group in p-cyanoacetanilide may also occur via this mechanism.

A possible reaction mechanism for the alkaline hydrolysis of p-nitroacetanilide is

Table 9. Substituent constant values for correlation analysis of the series of seven para-substituted acetanilides.

Substituent	para-sigma	van der Waal's radii
H	0.000	0.120
Br	0.232	0.185
CN	1.000	0.320
F	0.062	0.147
OCH3	-0.268	0.260
CH3	-0.170	0.200
NO2	1.270	0.259

Note: For CN and NO2, para-sigma-negative values are listed.

Van der Waal's radii are reported in nanometers (nm.).

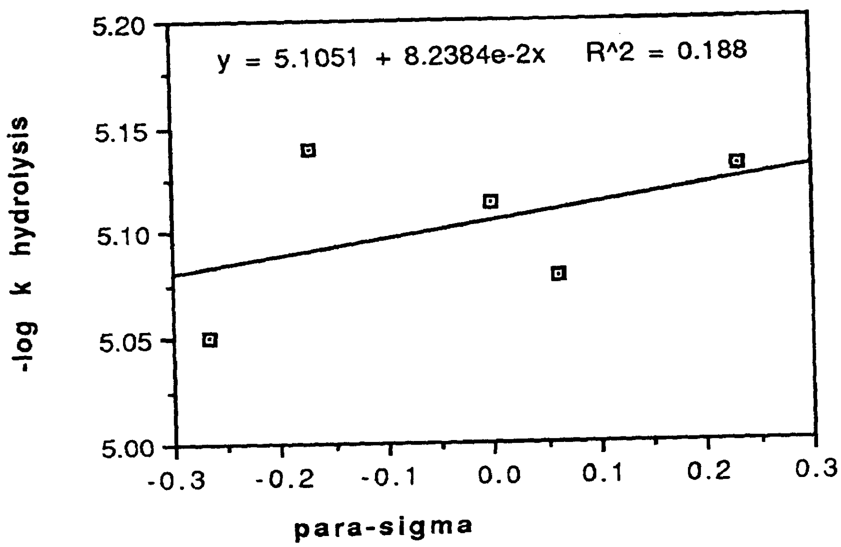

Figure 5. Plot of -log k_h versus σ_p for the alkaline hydrolysis of five para-substituted acetanilides.

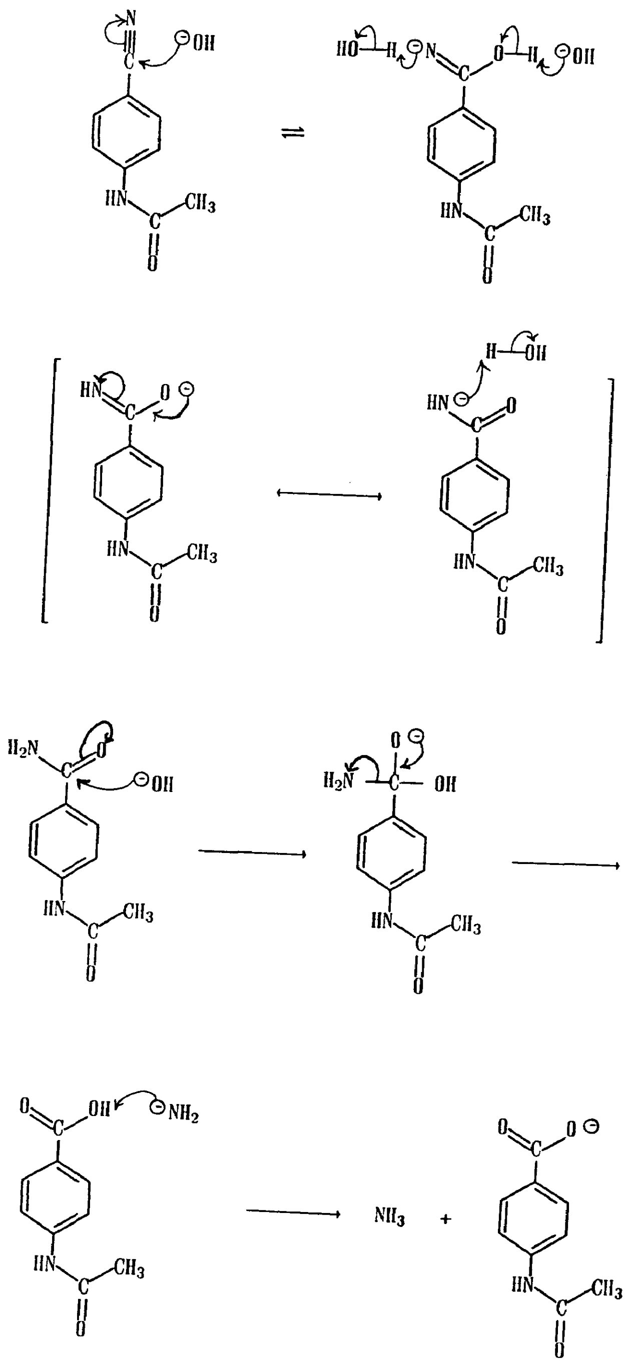

Figure 6. Reaction mechanism for hydrolysis of the nitrile substituent on para-cyanoacetanilide.

Adapted from March, J., 1985. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. Wiley-InterScience, N.Y., p. 788.

formation of a four-membered cyclic Meisenheimer complex intermediate (March, 1985). Attack by hydroxide ion at the ring carbon, instead of the carbonyl carbon, may be responsible for a second-order hydrolysis rate constant over 100 times larger than would be predicted from a LFER with Hammett σ constants. Formation of the intermediate as a cyclic Meisenheimer complex includes several resonance structures which are stabilized by electron delocalization. For clarity, only one resonance structure is represented in the reaction mechanism of Figure 7 for the alkaline hydrolysis of p-nitroacetanilide.

Bacterial Biolysis

Results of the kinetics for disappearance of reactant and appearance of product for bacterial biolysis of seven para-substituted acetanilides using four different pure bacterial cultures have been compiled in Tables 10 through 17. Although enzyme-catalyzed hydrolysis of these compounds was the primary reaction, para-substituted anilines were further transformed as evidenced by non-linear (concave downward) log plots of kinetic data for appearance of the aniline product. Not all bacterial transformation products were identified. Hence, rate constants calculated from kinetic data for the disappearance of para-substituted acetanilides were used in structure-activity correlation analyses.

Pseudo first-order biolysis rate constants ($k_{observed}$) were generated from a least squares regression of the log plot of substrate concentration versus time (see Appendix). If a lag phase occurred, as it did in biolysis experiments with the genera Pseudomonas and Bacillus, only linear kinetic data (ln [S] versus time) were used to calculate rate constants. The lag phase may be explained by these bacteria

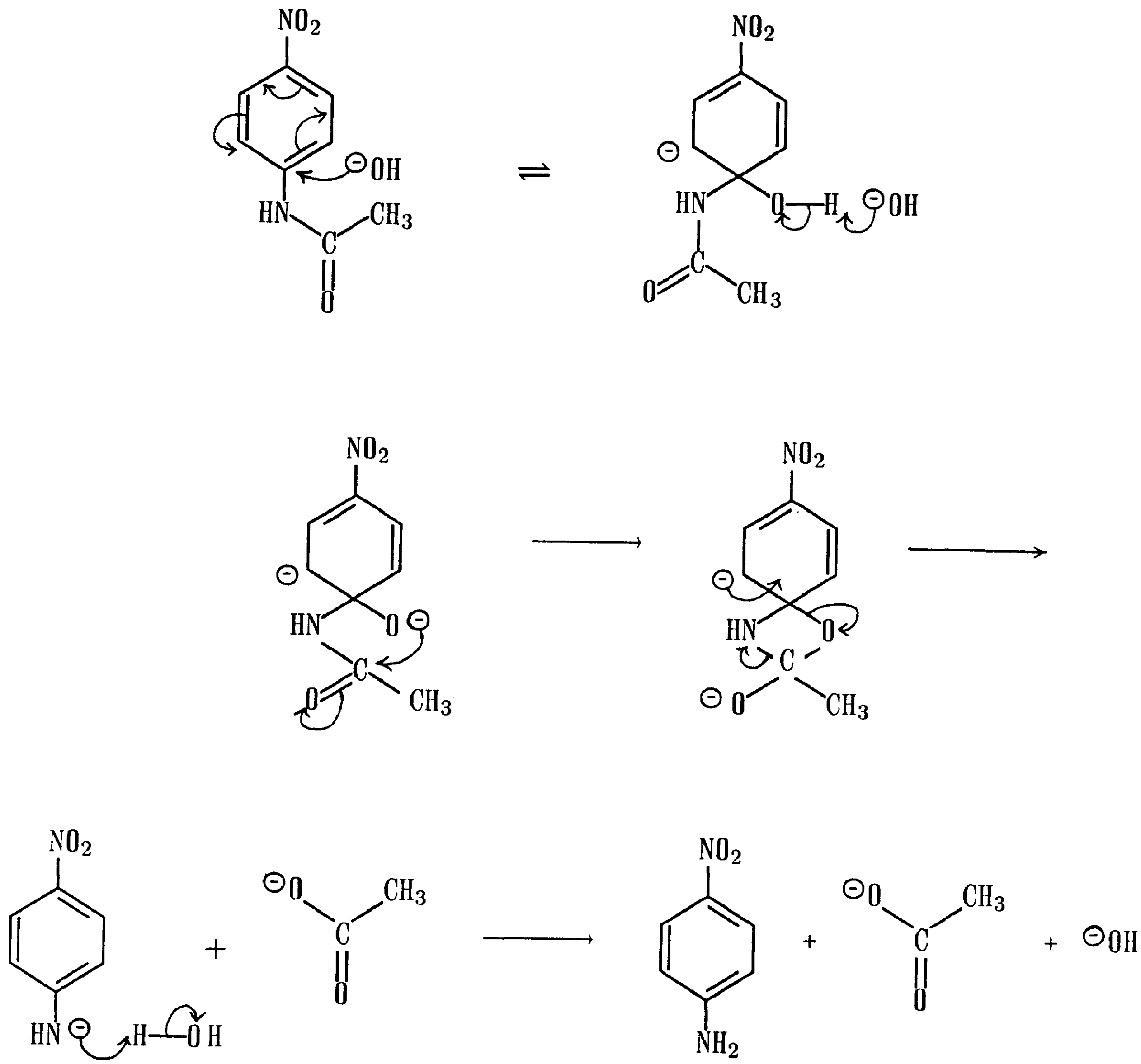

Figure 7. Reaction mechanism for the alkaline hydrolysis of para-nitroacetanilide.

Adapted from March, J., 1985. Advanced Organic Chemistry: Reactions, Mechanisms and Structure. Wiley-InterScience, N.Y., p. 577.

Table 10. Summary of kinetic results for bacterial biolysis experiments (disappearance of reactant) using Arthrobacter (CSMNS).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	1.13 ± 0.09	2.12 ± 0.28	2.14 ± 0.27	13.6696
	II	1.15 ± 0.07	2.16 ± 0.25		
para-bromo-	I	1.16 ± 0.19	2.18 ± 0.48	2.09 ± 0.44	13.6799
acetanilide	II	1.06 ± 0.15	1.99 ± 0.39		
para-cyano-	I	0.453 ± 0.037	0.852 ± 0.116	1.16 ± 0.16	13.9355
acetanilide	II	0.777 ± 0.064	1.46 ± 0.20		
para-fluoro-	I	1.03 ± 0.08	1.94 ± 0.26	1.89 ± 0.24	13.7235
acetanilide	II	0.978 ± 0.064	1.84 ± 0.22		
para-methoxy-	I	0.770 ± 0.034	1.45 ± 0.14	1.47 ± 0.15	13.8327
acetanilide	II	0.791 ± 0.036	1.49 ± 0.15		
para-methyl-	I	1.08 ± 0.13	2.03 ± 0.36	1.93 ± 0.24	13.7144
acetanilide	II	0.967 ± 0.013	1.82 ± 0.12		
para-nitro-	I	0.929 ± 0.095	1.75 ± 0.27	1.77 ± 0.27	13.7520
acetanilide	II	0.953 ± 0.090	1.79 ± 0.27		

Table 11. Summary of kinetic results for bacterial biolysis experiments (appearance of product) using Arthrobacter (CSMNS).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	1.45 ± 0.32	2.73 ± 0.75	2.75 ± 0.63	13.5607
	II	1.47 ± 0.19	2.76 ± 0.51		
para-bromo-	I	1.66 ± 0.18	3.12 ± 0.51	3.09 ± 0.48	13.5100
acetanilide	II	1.62 ± 0.15	3.05 ± 0.45		
para-cyano-	I	0.803 ± 0.060	1.51 ± 0.20	1.19 ± 0.16	13.9245
acetanilide	II	0.467 ± 0.041	0.878 ± 0.12		
para-fluoro-	I	2.43 ± 0.63	4.57 ± 1.76	4.62 ± 1.60	13.3354
acetanilide	II	2.48 ± 0.63	4.66 ± 1.44		
para-methoxy-	I	0.210 ± 0.015	0.395 ± 0.050	0.40 ± 0.05	14.3990
acetanilide	II	0.214 ± 0.017	0.402 ± 0.054		
para-methyl-	I	1.47 ± 0.27	2.76 ± 0.66	3.05 ± 0.70	13.5157
acetanilide	II	1.77 ± 0.29	3.33 ± 0.73		
para-nitro-	I	0.563 ± 0.015	1.06 ± 0.09	0.99 ± 0.074	14.0044
acetanilide	II	0.489 ± 0.018	0.919 ± 0.058		

Table 12. Summary of kinetic results for bacterial biolysis experiments (disappearance of reactant) using <u>Arthrobacter</u> (DSMP).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	4.75 ± 0.27	2.64 ± 0.34	2.62 ± 0.32	13.5817
	II	4.67 ± 0.20	2.59 ± 0.30		
para-bromo-	I	2.90 ± 0.10	1.61 ± 0.17	1.63 ± 0.18	13.7878
acetanilide	II	2.97 ± 0.11	1.65 ± 0.18		
para-cyano-	I	1.94 ± 0.09	1.08 ± 0.13	1.09 ± 0.13	13.9626
acetanilide	II	1.97 ± 0.09	1.09 ± 0.13		
para-fluoro-	I	3.69 ± 0.12	2.05 ± 0.21	2.04 ± 0.22	13.6904
acetanilide	II	3.65 ± 0.15	2.03 ± 0.23		
para-methoxy-	I	2.59 ± 0.08	1.44 ± 0.15	1.44 ± 0.15	13.8416
acetanilide	II	2.59 ± 0.09	1.44 ± 0.15		
para-methyl-	I	3.27 ± 0.11	1.82 ± 0.19	1.82 ± 0.20	13.7399
acetanilide	II	3.25 ± 0.13	1.81 ± 0.20		
para-nitro-	I	2.85 ± 0.12	1.58 ± 0.18	1.57 ± 0.19	13.8041
acetanilide	II	2.80 ± 0.15	1.56 ± 0.20		

Table 13. Summary of kinetic results for bacterial biolysis experiments (appearance of product) using Arthrobacter (DSMP).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	2.52 ± 0.15	1.40 ± 0.18	1.40 ± 0.18	13.8539
	II	2.51 ± 0.13	1.39 ± 0.17		
para-bromo-	I	2.99 ± 0.14	1.66 ± 0.20	1.75 ± 0.23	13.7570
acetanilide	II	3.32 ± 0.21	1.84 ± 0.25		
para-cyano-	I	2.52 ± 0.06	1.40 ± 0.13	1.30 ± 0.12	13.8861
acetanilide	II	2.14 ± 0.04	1.19 ± 0.11		
para-fluoro-	I	3.17 ± 0.22	1.76 ± 0.25	1.73 ± 0.24	13.7620
acetanilide	II	3.06 ± 0.19	1.70 ± 0.23		
para-methoxy-	I	0.301 ± 0.063	0.167 ± 0.047	0.18 ± 0.049	14.7545
acetanilide	II	0.331 ± 0.068	0.184 ± 0.051		
para-methyl-	I	2.09 ± 0.12	1.16 ± 0.15	1.18 ± 0.16	13.9281
acetanilide	II	2.14 ± 0.13	1.19 ± 0.16		
para-nitro-	I	2.16 ± 0.05	1.20 ± 0.11	1.26 ± 0.12	13.8996
acetanilide	II	2.37 ± 0.06	1.32 ± 0.13		

Table 14. Summary of kinetic results for bacterial biolysis experiments (disappearance of reactant) using Pseudomonas (CCS).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	1.68 ± 0.36	2.62 ± 0.78	2.60 ± 0.73	16.5850
	II	1.65 ± 0.28	2.57 ± 0.65		
para-bromo-	I	1.34 ± 0.30	2.09 ± 0.64	2.11 ± 0.64	16.6757
acetanilide	II	1.36 ± 0.30	2.12 ± 0.64		
para-cyano-	I	0.732 ± 0.012	1.14 ± 0.11	1.24 ± 0.12	16.9066
acetanilide	II	0.859 ± 0.011	1.34 ± 0.13		
para-fluoro-	I	2.19 ± 0.38	3.41 ± 0.87	3.24 ± 0.81	16.4895
acetanilide	II	1.97 ± 0.31	3.07 ± 0.74		
para-methoxy-	I	0.634 ± 0.151	0.988 ± 0.317	1.11 ± 0.27	16.9547
acetanilide	II	0.792 ± 0.109	1.23 ± 0.220		
para-methyl-	I	1.00 ± 0.14	1.56 ± 0.35	1.56 ± 0.36	16.8069
acetanilide	II	1.00 ± 0.15	1.56 ± 0.36		
para-nitro-	I	0.856 ± 0.162	1.33 ± 0.36	1.37 ± 0.28	16.8633
acetanilide	II	0.908 ± 0.078	1.41 ± 0.19		

Table 15. Summary of kinetic results for bacterial biolysis experiments (appearance of product) using Pseudomonas (CCS).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	0.236 ± 0.011	0.368 ± 0.048	0.34 ± 0.10	17.4672
	II	0.201 ± 0.078	0.313 ± 0.147		
para-bromo-	I	3.85 ± 1.13	6.00 ± 2.26	6.32 ± 2.52	16.1993
acetanilide	II	4.26 ± 1.43	6.64 ± 2.78		
para-cyano-	I	1.32 ± 0.15	2.06 ± 0.40	2.35 ± 0.62	16.6289
acetanilide	II	1.70 ± 0.40	2.65 ± 0.84		
para-fluoro-	I	1.77 ± 0.31	2.76 ± 0.71	2.35 ± 0.71	16.6289
acetanilide	II	1.24 ± ----	1.93 ± ----		
para-methoxy-	I	0.411 ± 0.053	0.640 ± 0.135	0.57 ± 0.13	17.2449
acetanilide	II	0.319 ± 0.053	0.497 ± 0.124		
para-methyl-	I	0.691 ± 0.078	1.08 ± 0.21	1.16 ± 0.22	16.9355
acetanilide	II	0.797 ± 0.083	1.24 ± 0.23		
para-nitro-	I	1.08 ± 0.24	1.68 ± 0.51	1.44 ± 0.37	16.8416
acetanilide	II	0.772 ± 0.085	1.20 ± 0.23		

Table 16. Summary of kinetic results for bacterial biolysis experiments (disappearance of reactant) using Bacillus (B.EPA).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	8.52 ± 1.64	8.52 ± 2.15	8.32 ± 2.07	18.0799
	II	8.11 ± 1.49	8.11 ± 1.98		
para-bromo-	I	7.61 ± 1.38	7.61 ± 1.84	7.59 ± 1.66	18.1198
acetanilide	II	7.57 ± 1.12	7.57 ± 1.57		
para-cyano-	I	5.24 ± 0.69	5.24 ± 1.00	5.28 ± 0.99	18.2774
acetanilide	II	5.32 ± 0.66	5.32 ± 0.98		
para-fluoro-	I	10.73 ± 1.80	10.73 ± 2.44	10.60 ± 2.54	17.9747
acetanilide	II	10.47 ± 2.00	10.47 ± 2.63		
para-methoxy-	I	5.14 ± 0.60	5.14 ± 0.91	5.20 ± 0.95	18.2840
acetanilide	II	5.26 ± 0.66	5.26 ± 0.98		
para-methyl-	I	7.36 ± 1.06	7.36 ± 1.50	7.32 ± 1.47	18.1355
acetanilide	II	7.28 ± 0.99	7.28 ± 1.43		
para-nitro-	I	6.42 ± 1.26	6.42 ± 1.65	6.23 ± 1.72	18.2055
acetanilide	II	6.03 ± 1.43	6.03 ± 1.79		

Table 17. Summary of kinetic results for bacterial biolysis experiments (appearance of product) using Bacillus (B.EPA).

Compound/ Replicate		k observed (10E4 sec-1)	k biolysis (10E14 sec-1 org.-1 L.)	average k biolysis (10E14 sec-1 org.-1 L.)	-log average k biolysis
acetanilide	I	6.48 ± 0.55	6.48 ± 0.94	6.95 ± 1.11	18.1580
	II	7.41 ± 0.84	7.41 ± 1.28		
para-bromo-	I	8.27 ± 0.89	8.27 ± 1.39	8.50 ± 1.46	18.0706
acetanilide	II	8.73 ± 1.00	8.73 ± 1.52		
para-cyano-	I	8.23 ± 1.52	8.23 ± 2.01	8.92 ± 2.30	18.0496
acetanilide	II	9.61 ± 2.00	9.61 ± 2.58		
para-fluoro-	I	7.51 ± 0.98	7.51 ± 1.43	8.17 ± 1.70	18.0878
acetanilide	II	8.82 ± 1.43	8.82 ± 1.96		
para-methoxy-	I	1.63 ± 0.34	1.63 ± 0.44	1.77 ± 0.37	18.7520
acetanilide	II	1.91 ± 0.46	1.91 ± 0.30		
para-methyl-	I	5.87 ± 0.96	5.87 ± 1.31	6.19 ± 1.47	18.2083
acetanilide	II	6.51 ± 1.24	6.51 ± 1.63		
para-nitro-	I	2.52 ± 0.21	2.52 ± 0.36	2.88 ± 0.46	18.5406
acetanilide	II	3.24 ± 0.36	3.24 ± 0.55		

synthesizing an inducible/adaptive hydrolase enzyme or coenzyme in response to para-substituted acetanilide substrate molecules, resulting in relative changes of enzyme-substrate concentrations. As synthesis of the hydrolase enzyme continues, the rate of hydrolysis increases in response to larger enzyme concentration.

All bacteria used in the kinetic studies were pure cultures (not mixed populations) identified as aerobic heterotrophs of the genera Arthrobacter, Pseudomonas, and Bacillus (Stanier, Palleroni and Doudoroff, 1966; Buchanan and Gibbons, 1974; Stanier et al., 1981; Krieg and Holt, 1984). Results of bacterial characterization and identification are presented in Table 18.

Average cell concentrations (over reaction time), reported in Table 19 as organisms/L., were used to calculate second-order biolysis rate constants. No significant change in cell concentrations was observed throughout the course of resting cell biolysis experiments, except for the genus Pseudomonas (sample CCS). Cell concentrations of Pseudomonas (CCS) increased from 5.90×10^{12} to 6.95×10^{12} org./L. over a 24 hour period.

Typical plots of substrate concentration versus time using p-methylacetanilide as a representative compound for Arthrobacter (CSMNS), Arthrobacter (DSMP), Pseudomonas (CCS), and Bacillus (B.EPA) biolysis experiments are illustrated in Figures 8 through 11, respectively.

Attempts to correlate second-order biolysis rate constants with such physico-chemical substituent properties of the para-substituted acetanilide molecules as pK_a (Lyman, Rheel and Rosenblatt, 1982), log K_{ow} (Chou and Jurs, 1979), Hansch's π (Hansch and Fujita, 1964; Hansch et al., 1973), Taft's E_s (Taft, 1952, 1956) and Hammett's σ_p (Jaffe, 1953) proved unsuccessful, i.e. linear regression yielded

Table 18. Genus identification of acetanilide-utilizing cultures used in bacterial biolysis experiments.

Sample Name	Culture Characteristics	Cell Characteristics	Genus
CSMNS	Whole colony - circular Edge - entire Color - white Elevation - convex Surface - smooth	Shape - rods and cocci Size - 2-10 um. long Motility - no Endospores - no Gram Stain - positive	Arthrobacter
DSMP	Whole colony - circular Edge - entire Color - white Elevation - convex Surface - smooth	Shape - rods and cocci Size - 2-20 um. long Motility - no Endospores - no Gram Stain - positive	Arthrobacter
B.EPA	Whole colony - irregular Edge - undulate Color - white Elevation - convex Surface - rough	Shape - rods Size - 2-6 um. long Motility - yes Endospores - yes Gram Stain - positive	Bacillus
CCS	Whole colony - circular Edge - entire Color - white Elevation - convex Surface - smooth	Shape - rods Size - 2-10 um. long Motility - yes Endospores - no Gram Stain - negative	Pseudomonas

Table 19. Cell concentrations for bacterial biolysis experiments.

Sample Name	Time (hours)	Direct Microscopic Count (org./L.)	Plate Count * (CFU/liter)	Average Cell Concentration (organisms/liter)
CSMNS	0.0	5.69E+09	5.15E+09	5.32 ± 0.29 E+09
	4.0		5.40E+09	(n=4)
	8.0		5.05E+09	
DSMP	0.0	1.83E+09	1.65E+09	1.80 ± 0.13 E+09
	4.0		1.95E+09	(n=4)
	8.0		1.75E+09	
B.EPA	0.0	1.01E+13		1.00 ± 0.06 E+14
	12.0	1.06E+13		(n=3)
	24.0	9.40E+12		
CCS	0.0	5.90E+12		6.42 ± 0.53 E+12
	12.0	6.40E+12		(n=3)
	24.0	6.95E+12		

* - It is assumed that 1 colony forming unit (CFU) = 1 organism.

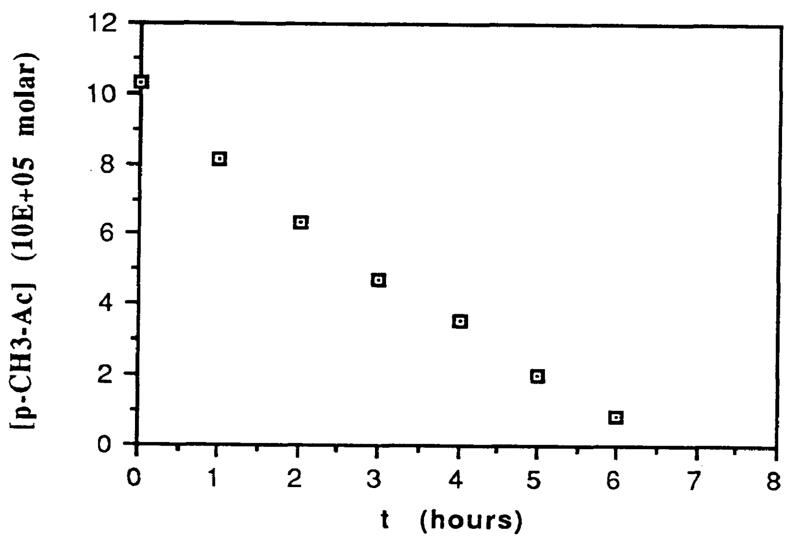

Figure 8. Plot of para-methylacetanilide concentration versus time for bacterial biolysis experiments using Arthrobacter (CSMNS).

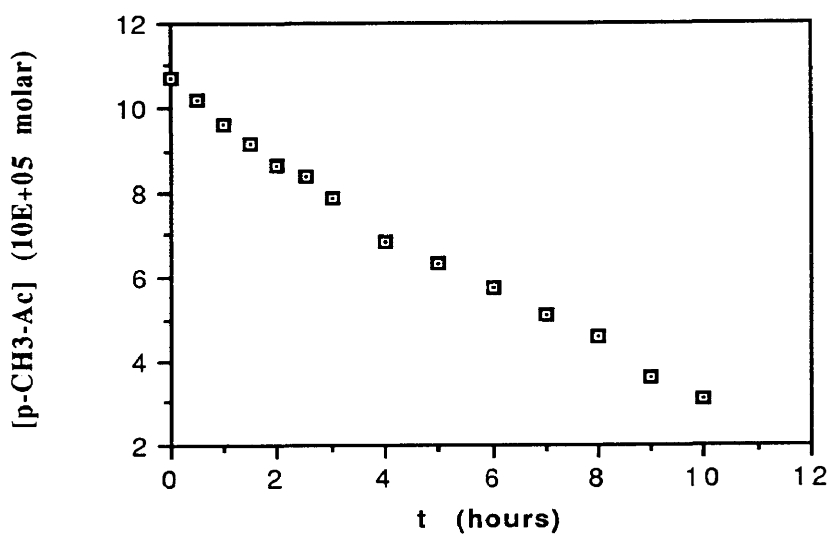

Figure 9. Plot of para-methylacetanilide concentration versus time for bacterial biolysis experiments using Arthrobacter (DSMP).

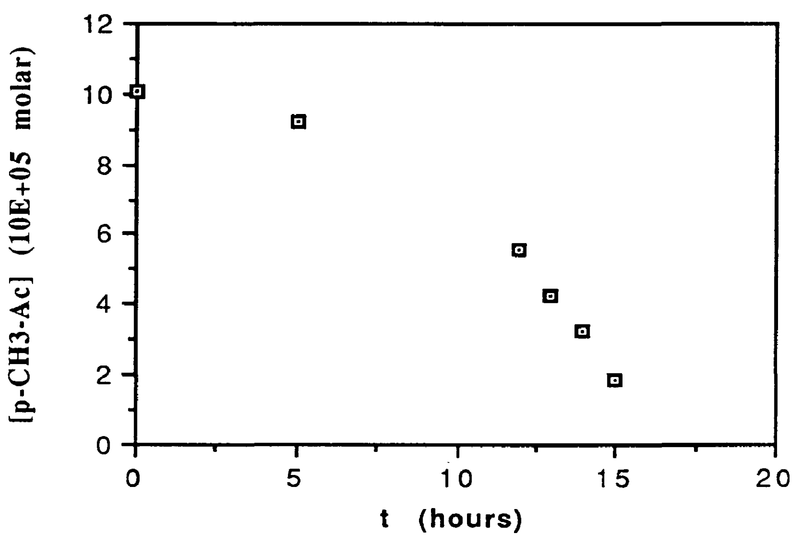

Figure 10. Plot of para-methylacetanilide concentration versus time for bacterial biolysis experiments using Pseudomonas (CCS).

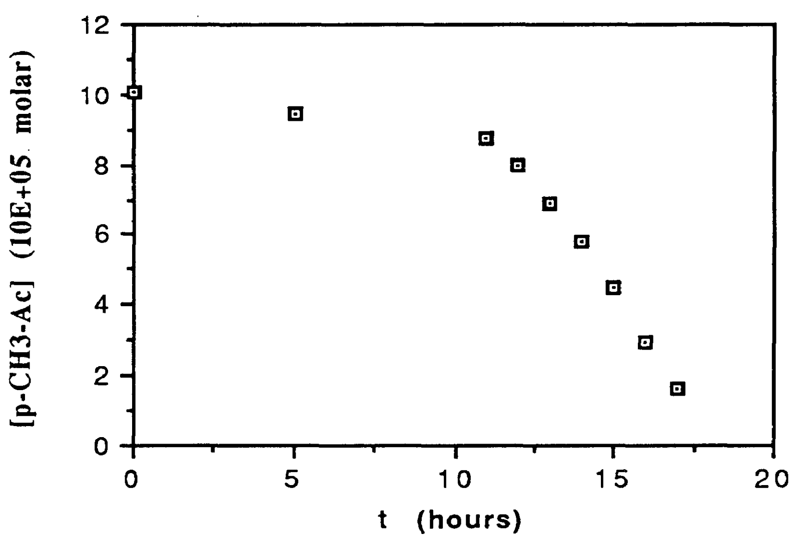

Figure 11. Plot of para-methylacetanilide concentration versus time for bacterial biolysis experiments using Bacillus (B.EPA).

correlation coefficients (r^2) < 0.50. However, good correlations ($r^2 = 0.90$) were demonstrated with the steric substituent constants, van der Waal's radii, γ_{vdw} (Bondi, 1964; Charton, 1969). Hence, structure-activity correlation analysis using γ_{vdw} was performed on all four bacterial cultures for which kinetic biolysis experiments were run.

Arthrobacter (CSMNS). From an average cell concentration of 5.32×10^9 organisms/L., calculated second-order biolysis rate constants for the seven substrates ranged from 1.16×10^{-14} to 2.14×10^{-14} sec^{-1} org.$^{-1}$ L. Rate constants differed by less than a factor of 2 indicating a small substituent effect on the bacterial biolysis of this series of para-substituted acetanilides. Correlation of the negative logarithm of second-order biolysis rate constants for individual para-substituted acetanilides with their corresponding van der Waal's radii, γ_{vdw}, yielded a linear regression with r^2 = 0.7822. The equation for the line is $y = 1.1762\ x + 13.5127$ (see Figure 12).

Arthrobacter (DSMP). From an average cell concentration of 1.80×10^9 organisms/L., calculated second-order biolysis rate constants for the seven substrates ranged from 1.09×10^{-14} to 2.62×10^{-14} sec^{-1} org.$^{-1}$ L. Rate constants differed by less than a factor of 3 indicating a small substituent effect on the bacterial biolysis of this series of para-substituted acetanilides. Correlation of the negative logarithm of second-order biolysis rate constants for individual para-substituted acetanilides with their corresponding van der Waal's radii, γ_{vdw}, yielded a linear regression with r^2 = 0.9049. The equation for the line is $y = 1.6212\ x + 13.4273$ (see Figure 13).

Pseudomonas (CCS). From an average cell concentration of 6.42×10^{12} organisms/L., calculated second-order biolysis rate constants for the seven substrates

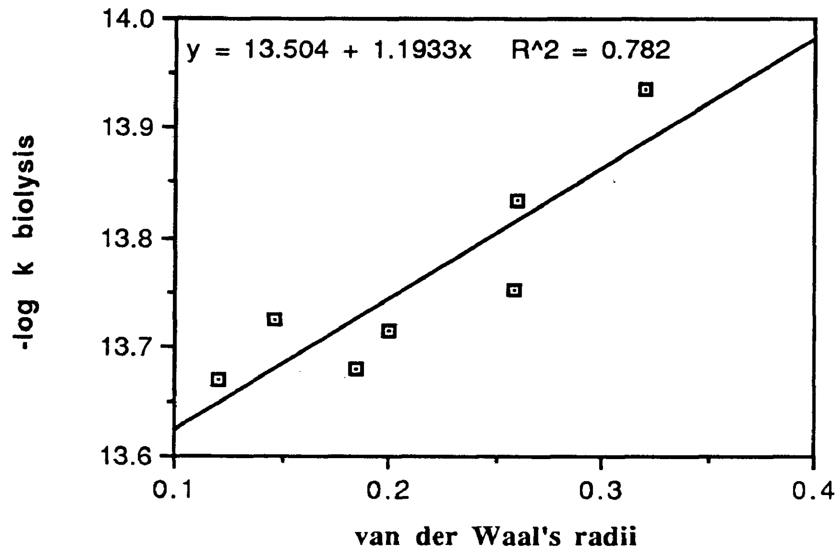

Figure 12. Plot of -log k_b versus γ_{vdw} for the bacterial biolysis of seven para-substituted acetanilides using Arthrobacter (CSMNS).

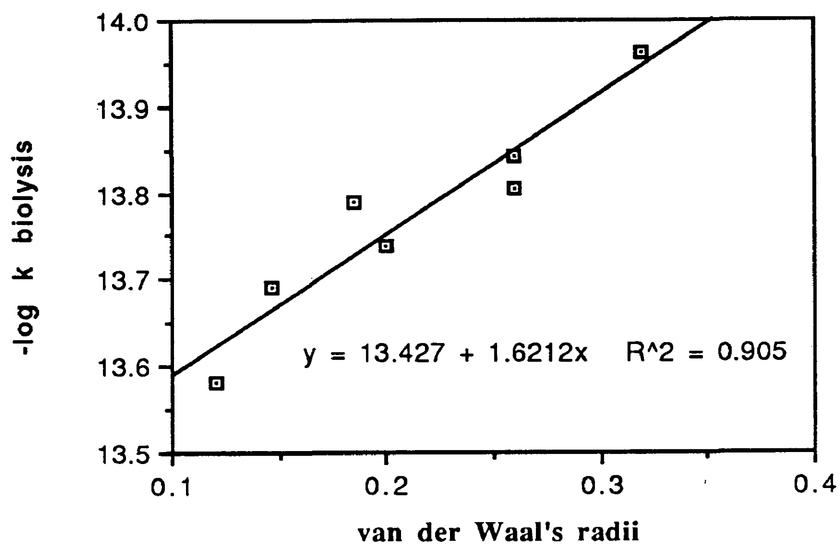

Figure 13. Plot of -log k_b versus γ_{vdw} for the bacterial biolysis of seven para-substituted acetanilides using Arthrobacter (DSMP).

ranged from 1.11 x 10^{-17} to 3.24 x 10^{-17} sec^{-1} $org.^{-1}$ L. Rate constants differed by less than a factor of 3 indicating a small substituent effect on the bacterial biolysis of this series of para-substituted acetanilides. Correlation of the negative logarithm of second-order biolysis rate constants for individual para-substituted acetanilides with their corresponding van der Waal's radii, γ_{vdw}, yielded a linear regression with r^2 = 0.7879. The equation for the line is y = 2.0425 x +16.3282 (see Figure 14).

Bacillus (B.EPA). From an average cell concentration of 1.00 x 10^{14} organisms/L., calculated second-order biolysis rate constants for the seven substrates ranged from 5.20 x 10^{-19} to 10.60 x 10^{-19} sec^{-1} $org.^{-1}$ L. Rate constants differed by approximately a factor of 2 indicating a small substituent effect on the bacterial biolysis of this series of para-substituted acetanilides. Correlation of the negative logarithm of second-order biolysis rate constants for individual para-substituted acetanilides with their corresponding van der Waal's radii, γ_{vdw}, yielded a linear regression with r^2 = 0.7875. The equation for the line is y = 1.3476 x +17.8726 (see Figure 15).

Similar slopes (1.1762 - 2.0425) in the correlations of second-order biolysis rate constants with van der Waal's radii suggest that the same enzyme-catalyzed hydrolysis mechanism is operative in all genera of bacteria investigated. Also, the same hydrolase enzyme or enzyme system may be responsible for the bacterial biolysis of para-substituted acetanilides in all cases.

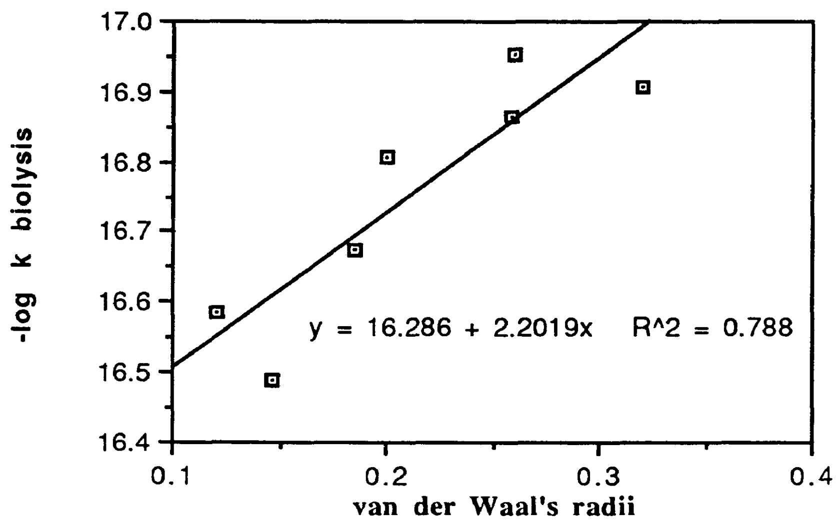

Figure 14. Plot of -log k_b versus γ_{vdw} for the bacterial biolysis of seven para-substituted acetanilides using Pseudomonas (CCS).

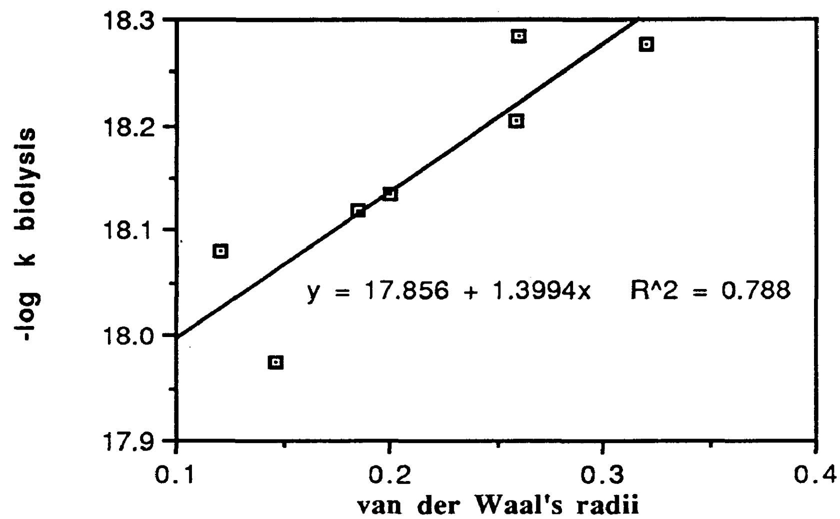

Figure 15. Plot of -log k_b versus γ_{vdw} for the bacterial biolysis of seven para-substituted acetanilides using Bacillus (B.EPA).

<u>Abiotic versus Biotic Hydrolysis</u>

In comparing the kinetics of alkaline hydrolysis with bacterial biolysis for this series of five para-substituted acetanilides (omitting the cyano and nitro compounds), results from <u>Arthrobacter</u> (sample DSMP) biolysis experiments were used as these kinetic data gave the best correlation with van der Waal's radii ($r^2 = 0.9049$). Linear regression of the negative logarithm of second-order hydrolysis rate constants versus the negative logarithm of second-order biolysis rate constants gave a correlation coefficient, r^2, of 0.0824. The equation for the line is $y = -0.8055\ x + 17.8385$ (see Figure 16). Both alkaline hydrolysis and bacterial biolysis are insensitive to substituent effects for these five substituents.

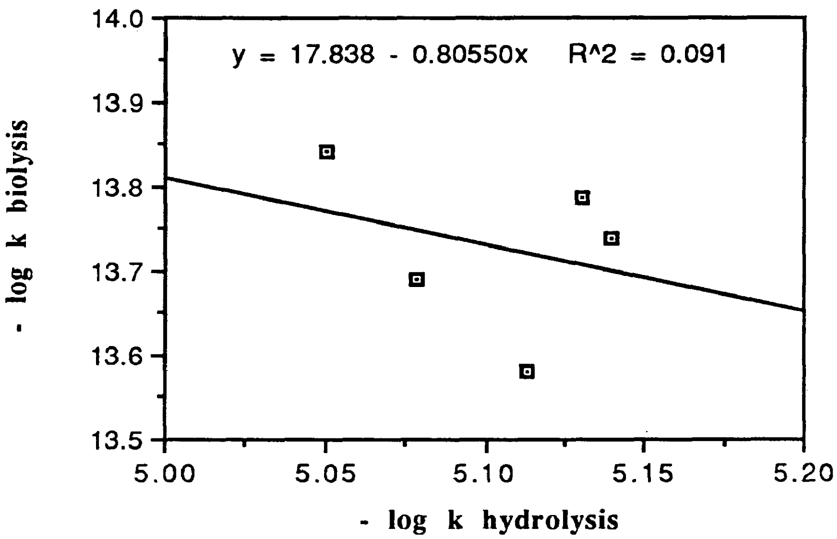

Figure 16. Plot of -log k_h versus -log k_b comparing alkaline hydrolysis and bacterial biolysis (Arthrobacter - DSMP) of five para-substituted acetanilides.

CONCLUSIONS

Several conclusions were derived from this research. Alkaline hydrolysis of p-bromo-, p-fluoro-, p-methoxy-, p-methyl-, and the unsubstituted acetanilide is insensitive to substituent effects as evidenced by the LFER reaction constant, ρ, of 0.082. Hydrolysis of the nitrile substituent for p-cyanoacetanilide and formation of a Meisenheimer complex for p-nitroacetanilide may explain the abnormally large rates of alkaline hydrolysis for these compounds.

Extrapolation to environmental conditions suggests that abiotic hydrolysis will be important in controlling the fate of acetanilide pesticides having strongly electron-withdrawing substituents such as p-cyano and p-nitro. Whereas, for p-bromo-, p-fluoro-, p-methoxy-, p-methyl-, and the unsubstituted acetanilide, abiotic hydrolysis, for a pH range most often encountered in aquatic and terrestrial ecosystems (pH 5-9), will not play a major role in controlling the fate of these compounds.

For biotic hydrolysis (bacterial biolysis) of this series of seven para-substituted acetanilides, second-order biolysis rate constants correlated well with the steric parameter, van der Waal's radii. It was demonstrated that common soil bacteria not only have the ability to utilize acetanilide compounds as a sole source of carbon and energy, but also transform these compounds primarily by mechanisms of enzyme-catalyzed hydrolysis. Relative activity for biolysis of para-substituted acetanilides by bacteria used in this study was as follows: Arthrobacter >> Pseudomonas > Bacillus. Substituent effects on biolysis rate constants were small for all bacteria investigated. The observed lag phase in biolysis experiments using Pseudomonas (sample CCS) and Bacillus (sample B.EPA) suggests synthesis of an adaptive hydrolase enzyme by these bacteria.

This research supports conclusions by Paris and Wolfe (1986,1987) for the microbal oxidation of substituted phenols and anilines correlating second-order rate constants to van der Waal's radii, γ_{vdw}. Steric parameters, i.e. the size and geometrical configuration of atoms or groups of atoms, may be useful in modeling environmental fate of para-substituted acetanilides and pesticides of similar molecular structure. Bacterial biolysis is an important process in the degradation of these organic chemicals under environmental conditions.

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APPENDIX OF KINETIC DATA

This appendix contains summaries of kinetic data for all alkaline hydrolysis and bacterial biolysis experiments conducted during this research project except the few preliminary studies performed for individual segments. Presentation of kinetic data is in the following order: alkaline hydrolysis, bacterial biolysis -- Arthrobacter (CSMNS), Arthrobacter (DSMP), Pseudomonas (CCS), and Bacillus (B.EPA). Compounds are listed alphabetically by substituent. Each data set is identified by experimental conditions, compound under investigation and replicate number.

Pseudo first-order rate constants, $k_{observed}$, are reported in sec^{-1} with corresponding statistical analysis. Correlation coefficients (r) and the sum of squared residuals (ssr) are given for rate constants calculated for disappearance of reactant para-substituted acetanilide and appearance of product para-substituted aniline.

Definitions of column abbreviations are as follows: t is time in minutes, hours or days; [Ac ave.] is the average concentration of para-substituted acetanilide; ln [Ac] is the natural logarithm of [Ac ave.]; [An ave.] is the average concentration of para-substituted aniline; and ln ([Ac0]-[An]) is the natural logarithm of the initial para-substituted acetanilide concentration minus the average para-substituted aniline concentration. An ERR in the last column indicates the concentration of hydrolysis product exceeded the initial average concentration of reactant compound.

Kinetic data are also represented graphically. Solid lines with rectangular data points are linear regressions of ln [Ac] versus time, while dotted lines with triangular data points are linear regressions of ln ([Ac0]-[An]) versus time.

Alkaline Hydrolysis, acetanilide, replicate 1				
k obs. (disappearance of reactant) = 7.35+/-0.12E-07 sec-1. r = 0.9985, b = -9.092+/-0.015, ssr = 0.00991.				
k obs. (appearance of product) = 3.83+/-0.22E-07 sec-1. r = 0.9830, b = -9.108+/-0.027, ssr = 0.0321.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	1.15E-04	-9.0749	0.00E+00	-9.0749
2.00	1.01E-04	-9.2007	8.93E-06	-9.1561
4.00	8.94E-05	-9.3223	1.74E-05	-9.2395
6.08	7.36E-05	-9.5168	2.49E-05	-9.3201
8.00	6.61E-05	-9.6240	2.91E-05	-9.3684
10.00	6.01E-05	-9.7192	3.74E-05	-9.4700
12.00	5.03E-05	-9.8983	4.17E-05	-9.5278
14.00	4.83E-05	-9.9381	5.13E-05	-9.6690
16.00	4.00E-05	-10.1263	5.19E-05	-9.6791
18.17	3.61E-05	-10.2285	5.12E-05	-9.6674
20.00	3.04E-05	-10.4010	5.05E-05	-9.6572
22.00	2.80E-05	-10.4837	5.89E-05	-9.7978
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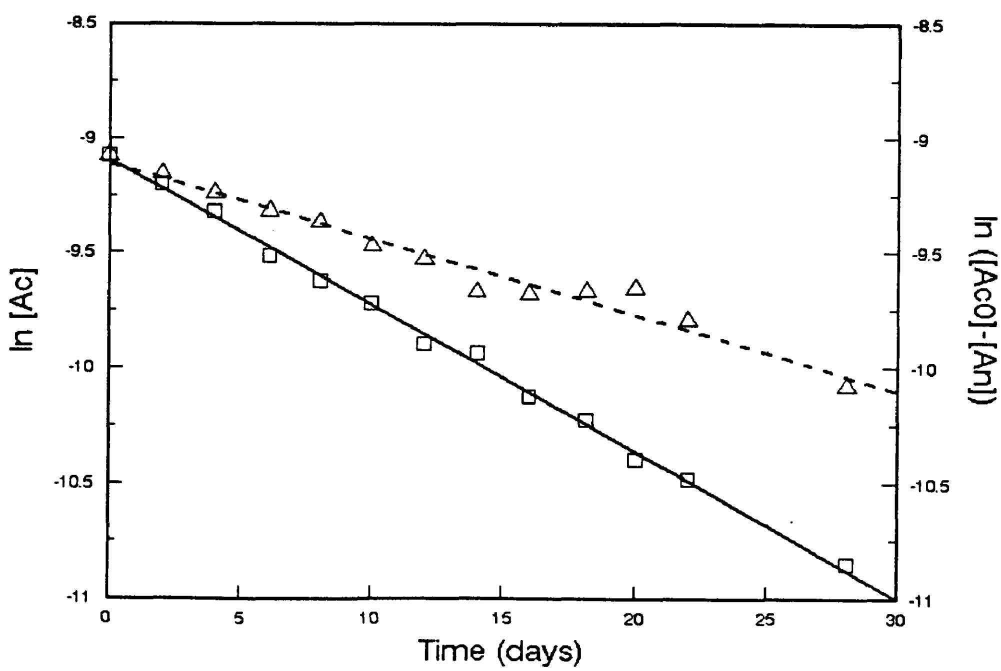
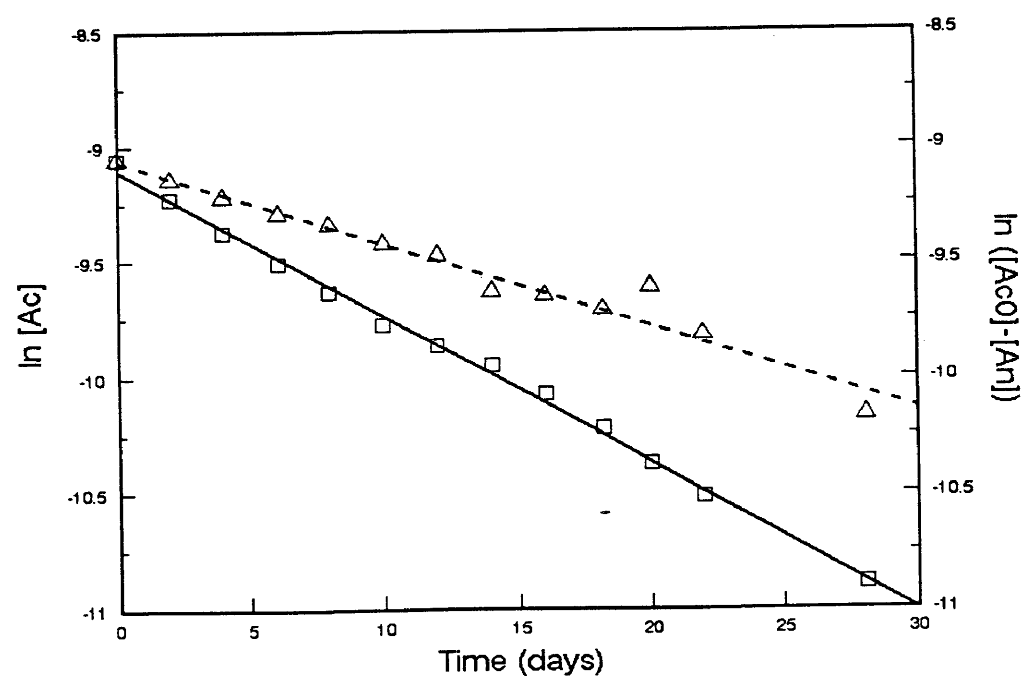
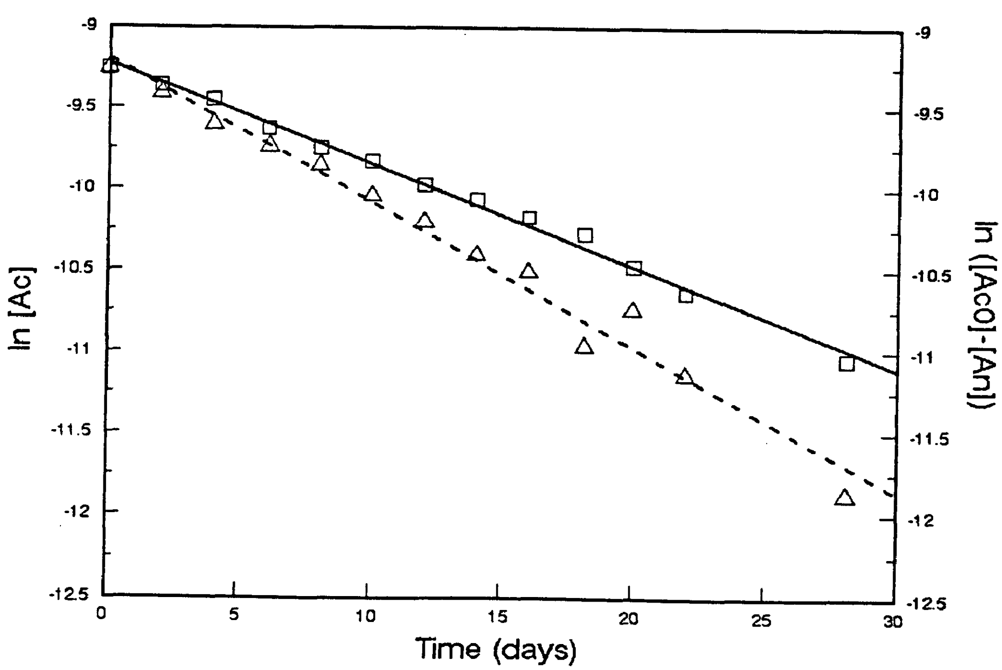


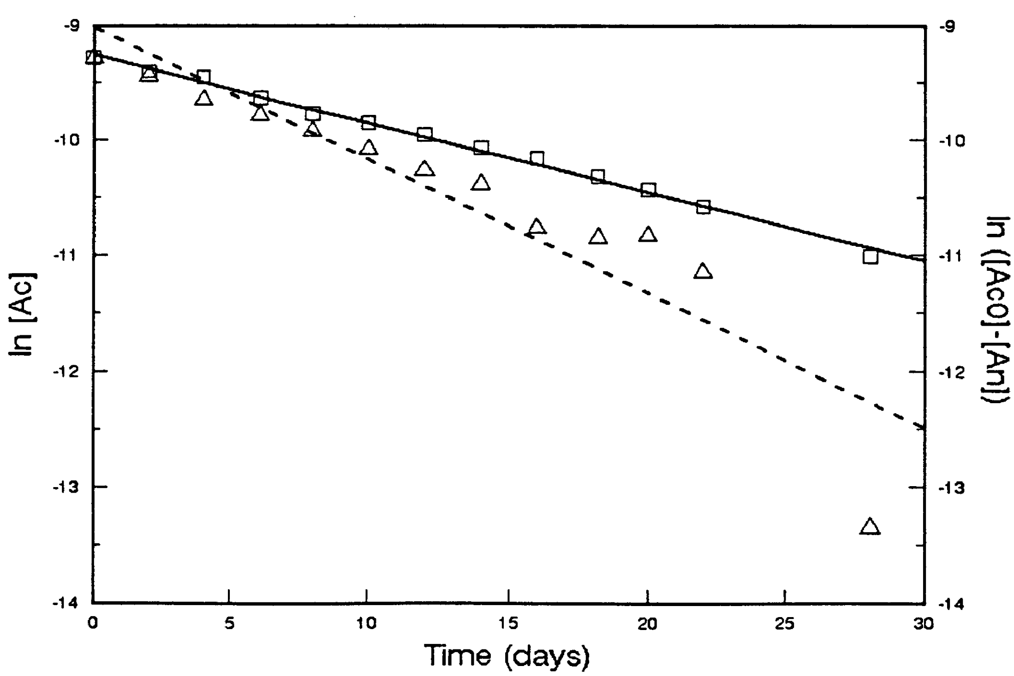
Alkaline Hydrolysis, acetanilide, replicate 2				
k obs. (disappearance of reactant) = 7.36+/-0.12E-07 sec-1. r = 0.9986, b = -9.098+/-0.015, ssr = 0.00964.				
k obs. (appearance of product) = 4.17+/-0.25E-07 sec-1. r = 0.9805, b = -9.061+/-0.032, ssr = 0.0439.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	1.17E-04	-9.0569	0.00E+00	-9.0569
2.00	9.86E-05	-9.2241	9.62E-06	-9.1430
4.00	8.49E-05	-9.3739	1.76E-05	-9.2203
6.08	7.41E-05	-9.5095	2.47E-05	-9.2947
8.00	6.56E-05	-9.6327	2.88E-05	-9.3404
10.00	5.68E-05	-9.7755	3.57E-05	-9.4224
12.00	5.19E-05	-9.8664	3.99E-05	-9.4754
14.00	4.76E-05	-9.9520	5.10E-05	-9.6324
16.00	4.21E-05	-10.0745	5.24E-05	-9.6542
18.17	3.63E-05	-10.2241	5.62E-05	-9.7154
20.00	3.11E-05	-10.3776	5.00E-05	-9.6164
22.00	2.71E-05	-10.5171	6.25E-05	-9.8248
28.08	1.86E-05	-10.8947	7.84E-05	-10.1728



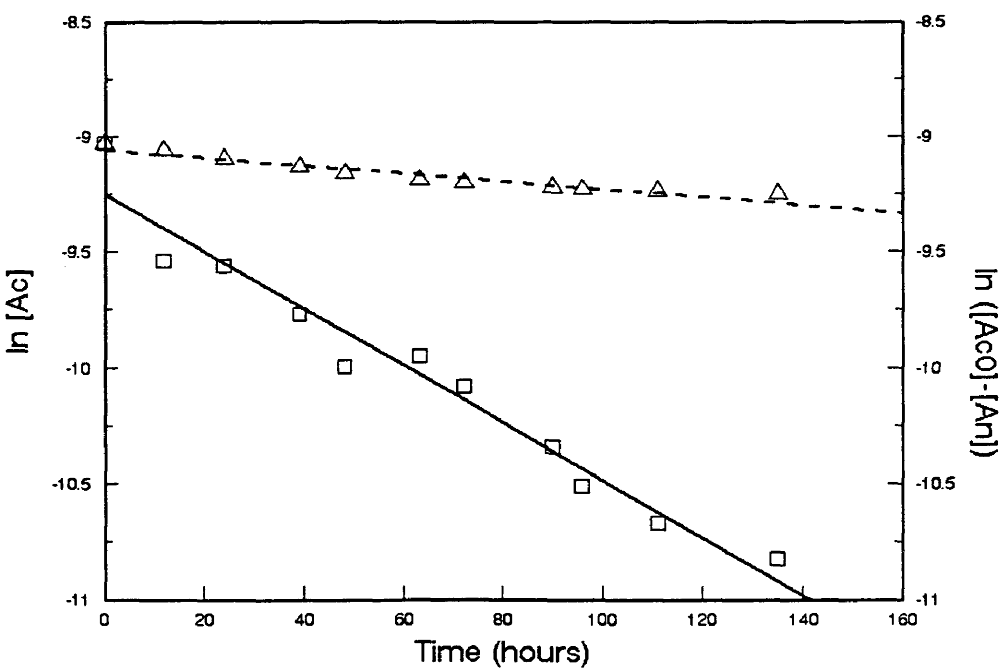
Alkaline Hydrolysis, p-Br-acetanilide, replicate 1				
k obs. (disappearance of reactant) = 7.23+/-0.17E-07 sec-1. r = 0.9969, b = -9.226+/-0.022, ssr = 0.0206.				
k obs. (appearance of product) = 1.03+/-0.04E-06 sec-1. r = 0.9897, b = -9.194+/-0.057, ssr = 0.139.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.52E-05	-9.2600	0.00E+00	-9.2600
2.00	8.55E-05	-9.3675	1.40E-05	-9.4187
4.00	7.84E-05	-9.4539	2.79E-05	-9.6073
6.08	6.56E-05	-9.6317	3.64E-05	-9.7420
8.00	5.82E-05	-9.7517	4.30E-05	-9.8605
10.00	5.36E-05	-9.8344	5.17E-05	-10.0440
12.00	4.63E-05	-9.9794	5.82E-05	-10.2059
14.00	4.24E-05	-10.0677	6.50E-05	-10.4084
16.00	3.82E-05	-10.1738	6.79E-05	-10.5107
18.17	3.45E-05	-10.2740	7.79E-05	-10.9662
20.00	2.82E-05	-10.4777	7.36E-05	-10.7446
22.00	2.39E-05	-10.6407	8.07E-05	-11.1429
28.08	1.60E-05	-11.0443	8.82E-05	-11.8753



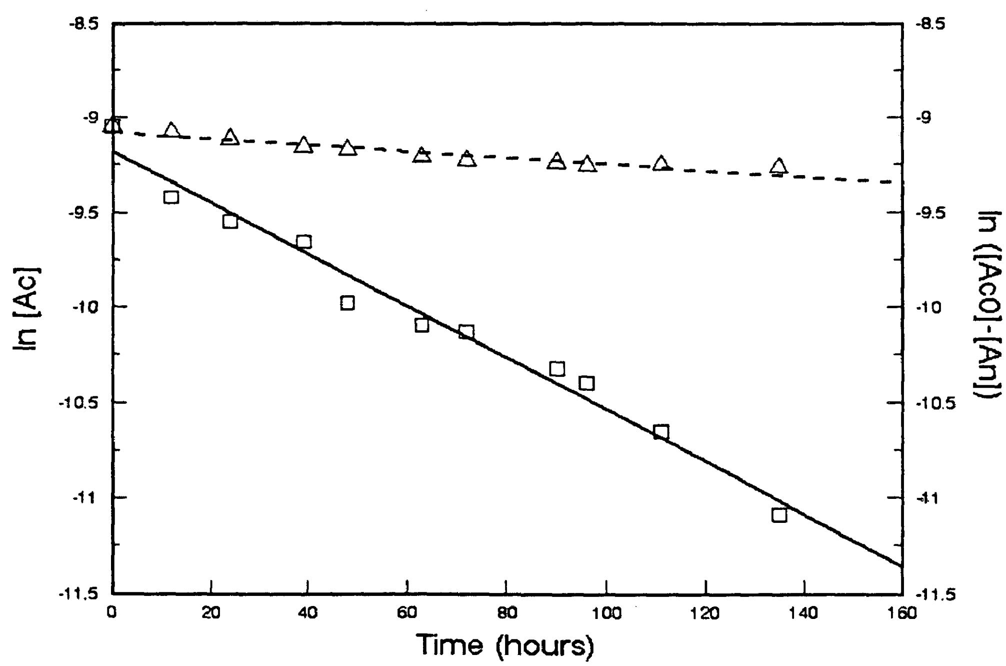
Alkaline Hydrolysis, p-Br-acetanilide, replicate 2				
k obs. (disappearance of reactant) = 6.91+/-0.15E-07 sec-1. r = 0.9974, b = -9.255+/-0.019, ssr = 0.0154.				
k obs. (appearance of product) = 9.65+/-0.33E-07 sec-1. r = 0.9942, b = -9.281+/-0.037, ssr = 0.0463.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.28E-05	-9.2846	0.00E+00	-9.2846
2.00	8.25E-05	-9.4026	1.37E-05	-9.4438
4.00	7.82E-05	-9.4557	2.86E-05	-9.6532
6.08	6.51E-05	-9.6390	3.65E-05	-9.7847
8.00	5.72E-05	-9.7687	4.38E-05	-9.9222
10.00	5.28E-05	-9.8491	5.10E-05	-10.0823
12.00	4.77E-05	-9.9497	5.79E-05	-10.2616
14.00	4.27E-05	-10.0620	6.18E-05	-10.3816
16.00	3.88E-05	-10.1574	7.16E-05	-10.7615
18.17	3.33E-05	-10.3112	7.33E-05	-10.8452
20.00	2.96E-05	-10.4271	7.31E-05	-10.8329
22.00	2.56E-05	-10.5715	7.84E-05	-11.1465
28.08	1.66E-05	-11.0033	9.13E-05	-13.3540



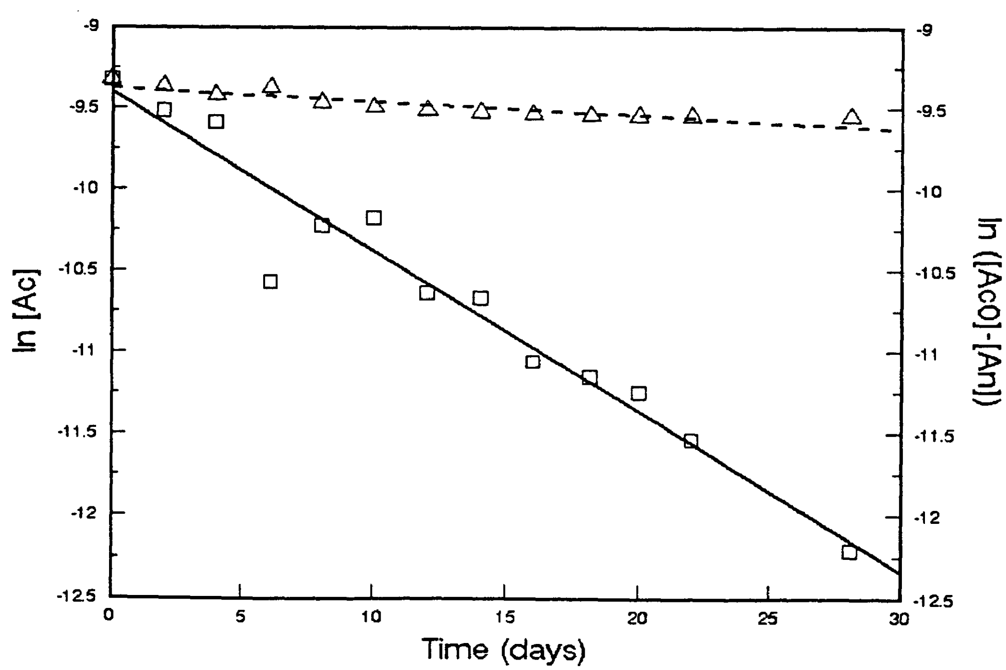
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.1 M, replicate 1.				
k obs. (disappearance of reactant) = 3.44+/-0.24E-06 sec-1. r = 0.9791, b = -9.249+/-0.064, ssr = 0.121.				
k obs. (appearance of product) = 4.69+/-0.46E-07 sec-1. r = 0.9588, b = -9.057+/-0.012, ssr = 0.00456.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.20E-04	-9.0272	0.00E+00	-9.0272
12.0	7.21E-05	-9.5369	3.70E-06	-9.0585
24.0	7.05E-05	-9.5592	8.00E-06	-9.0961
39.0	5.70E-05	-9.7723	1.20E-05	-9.1328
48.0	4.55E-05	-9.9969	1.50E-05	-9.1605
63.0	4.76E-05	-9.9533	1.79E-05	-9.1888
72.0	4.17E-05	-10.0845	1.90E-05	-9.1997
90.0	3.22E-05	-10.3444	2.10E-05	-9.2197
96.0	2.72E-05	-10.5131	2.18E-05	-9.2270
111.0	2.32E-05	-10.6708	2.27E-05	-9.2362
135.0	1.99E-05	-10.8236	2.38E-05	-9.2478



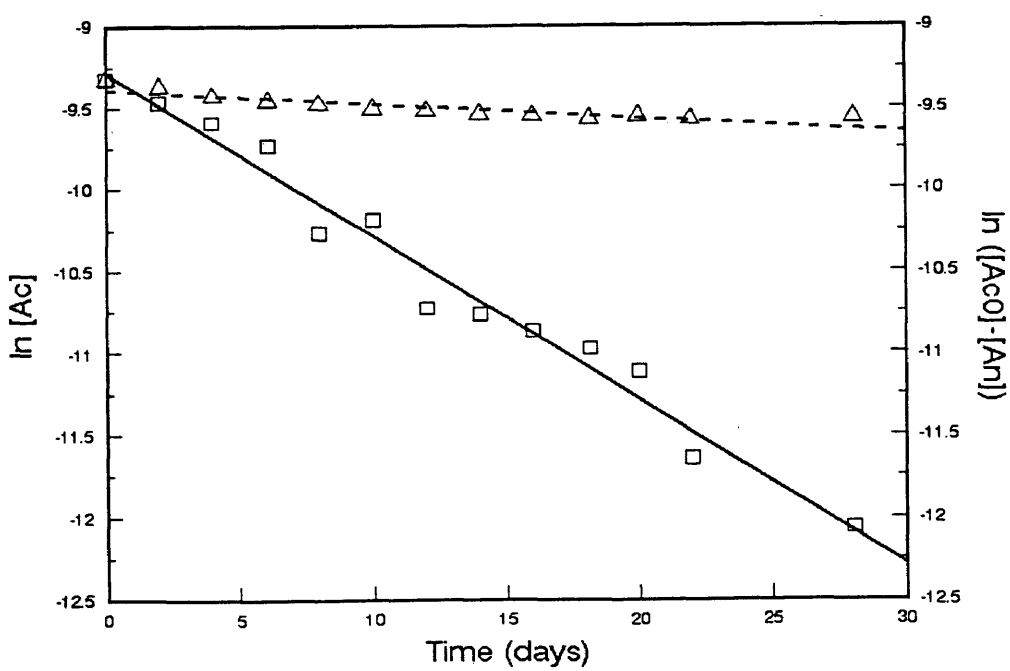
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.1 M, replicate 2.				
k obs. (disappearance of reactant) = 3.78+/-0.19E-06 sec-1. r = 0.9890, b = -9.179+/-0.051, ssr = 0.0754.				
k obs. (appearance of product) = 4.66+/-0.49E-07 sec-1. r = 0.9541, b = -9.078+/-0.013, ssr = 0.00512.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.18E-04	-9.0461	0.00E+00	-9.0461
12.0	8.08E-05	-9.4237	3.94E-06	-9.0801
24.0	7.11E-05	-9.5516	7.92E-06	-9.1156
39.0	6.39E-05	-9.6575	1.24E-05	-9.1571
48.0	4.64E-05	-9.9779	1.40E-05	-9.1724
63.0	4.12E-05	-10.0968	1.77E-05	-9.2084
72.0	3.99E-05	-10.1292	1.93E-05	-9.2247
90.0	3.28E-05	-10.3238	2.08E-05	-9.2402
96.0	3.04E-05	-10.4017	2.22E-05	-9.2545
111.0	2.37E-05	-10.6520	2.16E-05	-9.2483
135.0	1.52E-05	-11.0919	2.33E-05	-9.2659



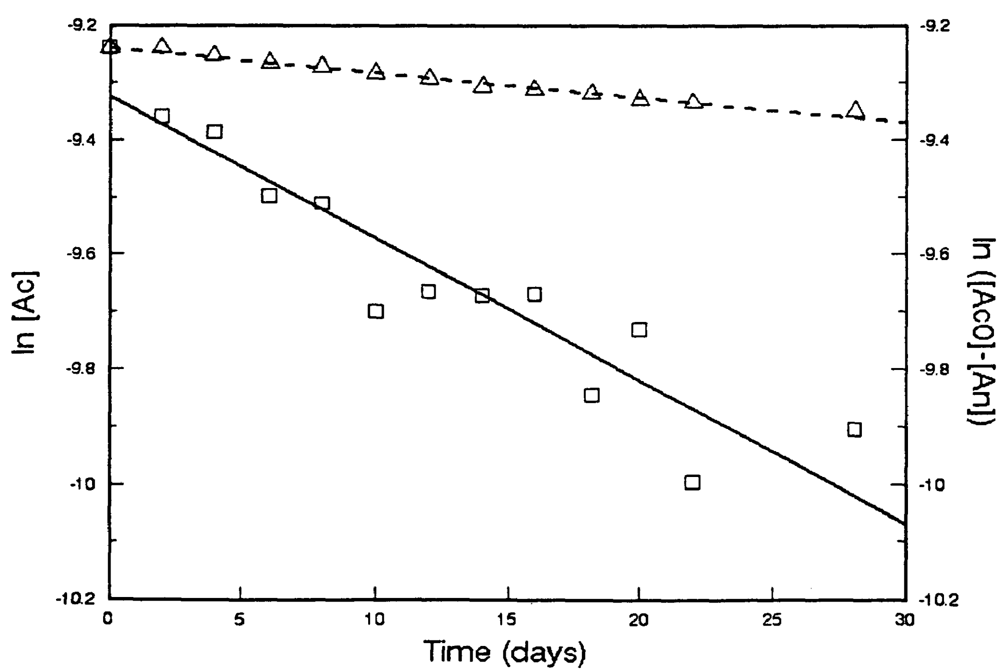
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.032 M, replicate 1.				
k obs. (disappearance of reactant) = 1.14+/-0.08E-06 sec-1. r = 0.9723, b = -9.400+/-0.105, ssr = 0.468.				
k obs. (appearance of product) = 9.88+/-1.50E-08 sec-1. r = 0.8935, b = -9.374+/-0.019, ssr = 0.0154.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	8.94E-05	-9.3228	0.00E+00	-9.3228
2.00	7.37E-05	-9.5160	3.99E-06	-9.3685
4.00	6.85E-05	-9.5893	8.59E-06	-9.4239
6.08	2.56E-05	-10.5727	4.58E-06	-9.3755
8.00	3.62E-05	-10.2277	1.23E-05	-9.4705
10.00	3.79E-05	-10.1806	1.44E-05	-9.4987
12.00	2.40E-05	-10.6383	1.54E-05	-9.5119
14.00	2.33E-05	-10.6691	1.64E-05	-9.5255
16.00	1.58E-05	-11.0581	1.71E-05	-9.5349
18.17	1.43E-05	-11.1534	1.78E-05	-9.5448
20.00	1.30E-05	-11.2484	1.81E-05	-9.5497
22.00	9.75E-06	-11.5382	1.82E-05	-9.5503
28.08	4.96E-06	-12.2140	1.83E-05	-9.5513



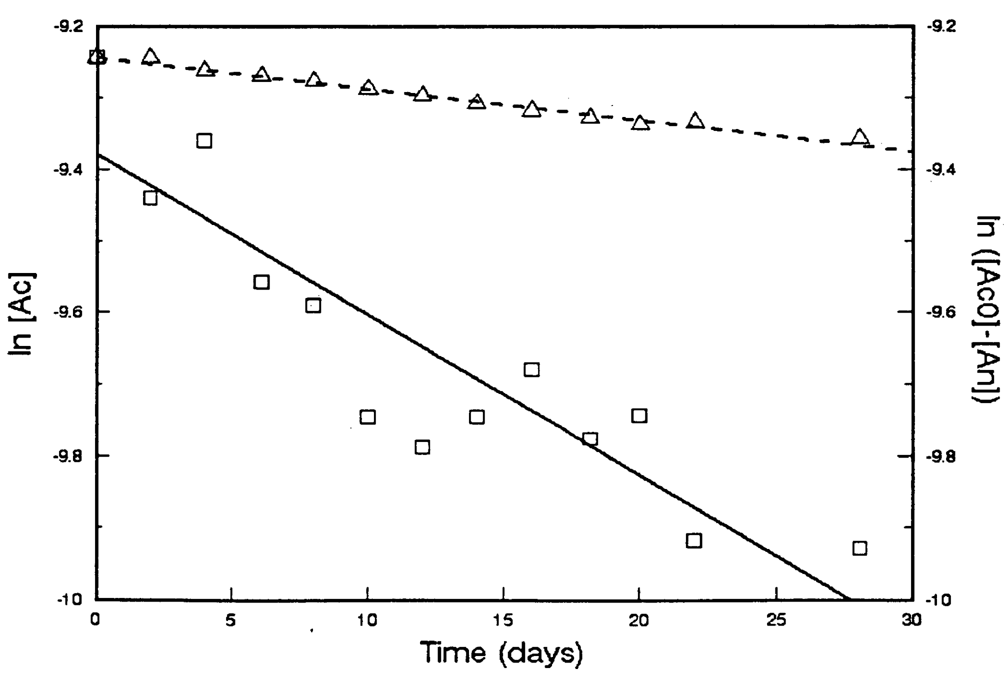
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.032 M, replicate 2.				
k obs. (disappearance of reactant) = 1.15+/-0.06E-06 sec-1. r = 0.9875, b = -9.288+/-0.071, ssr = 0.214.				
k obs. (appearance of product) = 9.97+/-1.43E-08 sec-1. r = 0.9028, b = -9.391+/-0.018, ssr = 0.0146.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	8.90E-05	-9.3273	0.00E+00	-9.3273
2.00	7.72E-05	-9.4691	3.83E-06	-9.3714
4.00	6.82E-05	-9.5927	8.69E-06	-9.4302
6.08	5.93E-05	-9.7335	1.10E-05	-9.4593
8.00	3.47E-05	-10.2700	1.25E-05	-9.4784
10.00	3.75E-05	-10.1903	1.48E-05	-9.5088
12.00	2.19E-05	-10.7279	1.57E-05	-9.5211
14.00	2.12E-05	-10.7608	1.70E-05	-9.5396
16.00	1.90E-05	-10.8696	1.80E-05	-9.5540
18.17	1.71E-05	-10.9750	1.94E-05	-9.5734
20.00	1.49E-05	-11.1164	1.82E-05	-9.5565
22.00	8.79E-06	-11.6415	1.97E-05	-9.5783
28.08	5.77E-06	-12.0626	1.88E-05	-9.5642



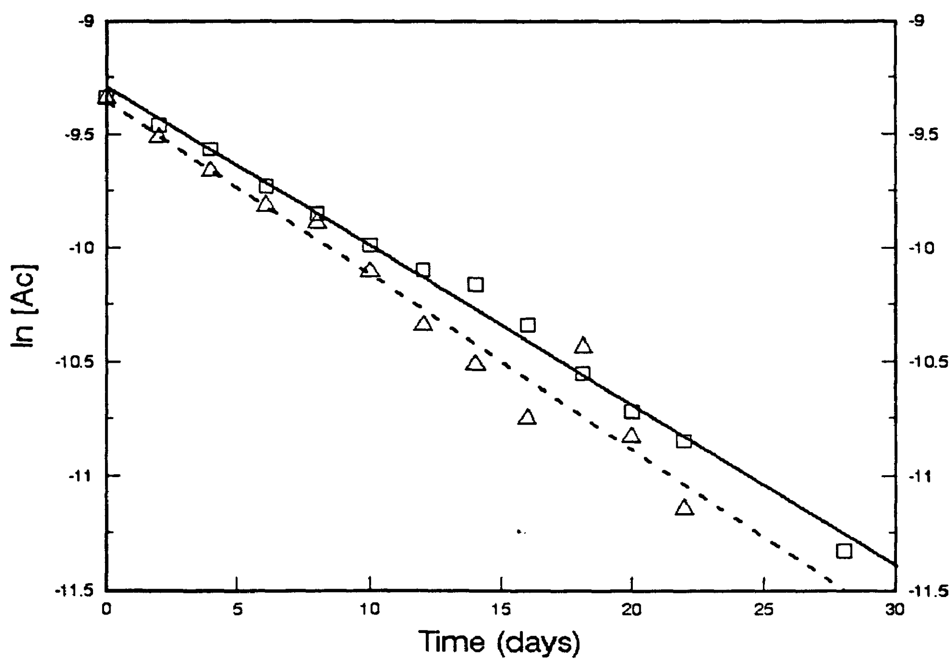
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.01 M, replicate 1.				
k obs. (disappearance of reactant) = 2.88+/-0.32E-07 sec-1. r = 0.9372, b = -9.322+/-0.041, ssr = 0.0725.				
k obs. (appearance of product) = 5.05+/-0.13E-08 sec-1. r = 0.9966, b = -9.238+/-0.002, ssr = 0.000278.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.72E-05	-9.2387	0.00E+00	-9.2387
2.00	8.62E-05	-9.3587	1.34E-08	-9.2389
4.00	8.39E-05	-9.3858	1.42E-06	-9.2534
6.08	7.50E-05	-9.4981	2.59E-06	-9.2657
8.00	7.40E-05	-9.5109	3.23E-06	-9.2725
10.00	6.13E-05	-9.6992	4.24E-06	-9.2834
12.00	6.35E-05	-9.6648	5.10E-06	-9.2926
14.00	6.31E-05	-9.6712	6.32E-06	-9.3060
16.00	6.31E-05	-9.6701	6.84E-06	-9.3117
18.17	5.30E-05	-9.8453	7.55E-06	-9.3196
20.00	5.94E-05	-9.7319	8.43E-06	-9.3295
22.00	4.55E-05	-9.9968	8.97E-06	-9.3355
28.08	4.99E-05	-9.9046	1.02E-05	-9.3498



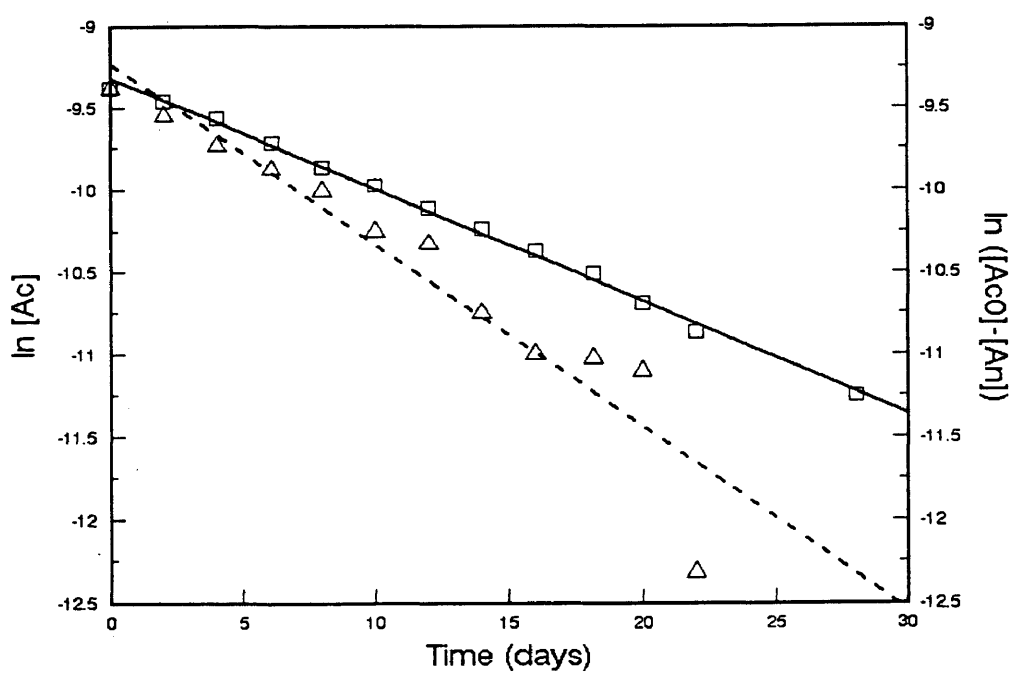
Alkaline Hydrolysis, p-CN-acetanilide, [OH-] = 0.01 M, replicate 2.				
k obs. (disappearance of reactant) = 2.59+/-0.37E-07 sec-1. r = 0.9031, b = -9.379+/-0.047, ssr = 0.0955.				
k obs. (appearance of product) = 5.04+/-0.24E-08 sec-1. r = 0.9879, b = -9.244+/-0.003, ssr = 0.000271.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.68E-05	-9.2433	0.00E+00	-9.2433
2.00	7.94E-05	-9.4410	9.70E-08	-9.2443
4.00	8.61E-05	-9.3595	1.83E-06	-9.2624
6.08	7.06E-05	-9.5578	2.52E-06	-9.2698
8.00	6.84E-05	-9.5899	3.22E-06	-9.2772
10.00	5.85E-05	-9.7463	4.18E-06	-9.2875
12.00	5.61E-05	-9.7883	5.03E-06	-9.2967
14.00	5.85E-05	-9.7458	6.07E-06	-9.3082
16.00	6.25E-05	-9.6804	6.94E-06	-9.3178
18.17	5.68E-05	-9.7759	7.86E-06	-9.3281
20.00	5.87E-05	-9.7433	8.65E-06	-9.3370
22.00	4.93E-05	-9.9180	8.41E-06	-9.3343
28.08	4.88E-05	-9.9278	1.04E-05	-9.3573



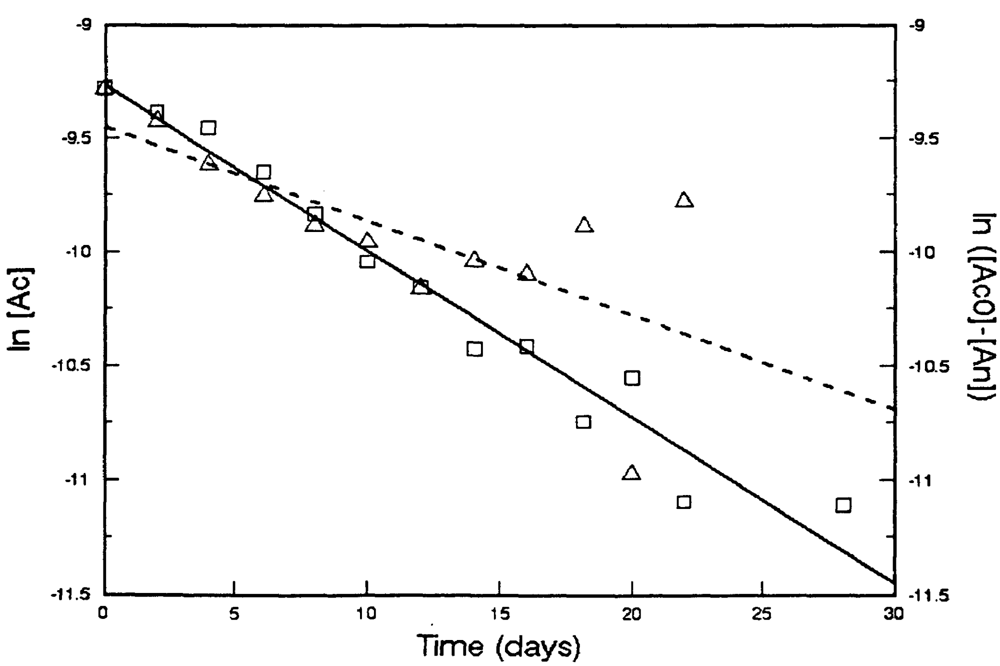
Alkaline Hydrolysis, p-F-acetanilide, replicate 1				
k obs. (disappearance of reactant) = 8.11+/-0.20E-07 sec-1. r = 0.9966, b = -9.291+/-0.026, ssr = 0.0286.				
k obs. (appearance of product) = 8.86+/-0.61E-07 sec-1. r = 0.9773, b = -9.354+/-0.068, ssr = 0.158.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	8.76E-05	-9.3422	0.00E+00	-9.3422
2.00	7.77E-05	-9.4628	1.40E-05	-9.5162
4.00	6.99E-05	-9.5685	2.42E-05	-9.6646
6.08	5.93E-05	-9.7328	3.32E-05	-9.8184
8.00	5.25E-05	-9.8543	3.71E-05	-9.8921
10.00	4.58E-05	-9.9914	4.68E-05	-10.1065
12.00	4.11E-05	-10.0996	5.55E-05	-10.3449
14.00	3.86E-05	-10.1614	6.06E-05	-10.5175
16.00	3.23E-05	-10.3408	6.62E-05	-10.7520
18.17	2.61E-05	-10.5544	5.83E-05	-10.4377
20.00	2.21E-05	-10.7196	6.79E-05	-10.8342
22.00	1.94E-05	-10.8497	7.32E-05	-11.1454
28.08	1.20E-05	-11.3306	9.57E-05	ERR



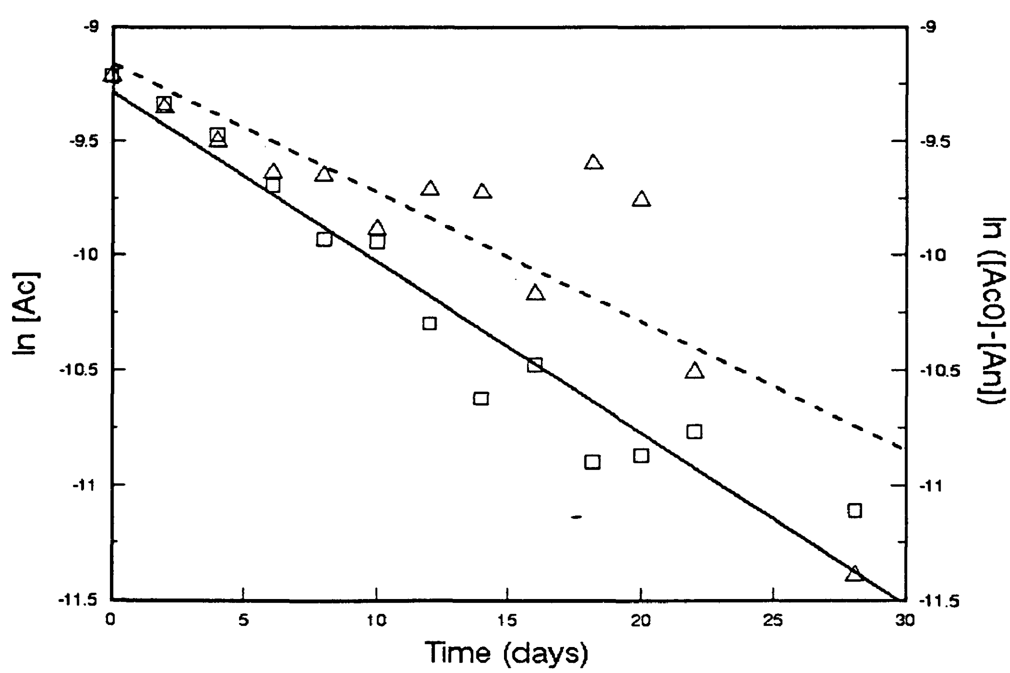
Alkaline Hydrolysis, p-F-acetanilide, replicate 2				
k obs. (disappearance of reactant) = 7.88+/-0.14E-07 sec-1. r = 0.9983, b = -9.314+/-0.018, ssr = 0.0134.				
k obs. (appearance of product) = 1.28+/-0.13E-06 sec-1. r = 0.9533, b = -9.227+/-0.144, ssr = 0.701.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	8.43E-05	-9.3815	0.00E+00	-9.3815
2.00	7.80E-05	-9.4589	1.29E-05	-9.5480
4.00	7.02E-05	-9.5648	2.50E-05	-9.7338
6.08	6.05E-05	-9.7136	3.30E-05	-9.8775
8.00	5.18E-05	-9.8680	3.92E-05	-10.0064
10.00	4.67E-05	-9.9725	4.91E-05	-10.2556
12.00	4.07E-05	-10.1094	5.15E-05	-10.3271
14.00	3.59E-05	-10.2360	6.28E-05	-10.7501
16.00	3.12E-05	-10.3753	6.76E-05	-11.0011
18.17	2.73E-05	-10.5102	6.79E-05	-11.0218
20.00	2.28E-05	-10.6892	6.92E-05	-11.1036
22.00	1.91E-05	-10.8655	7.98E-05	-12.3196
28.08	1.30E-05	-11.2503	1.01E-04	ERR



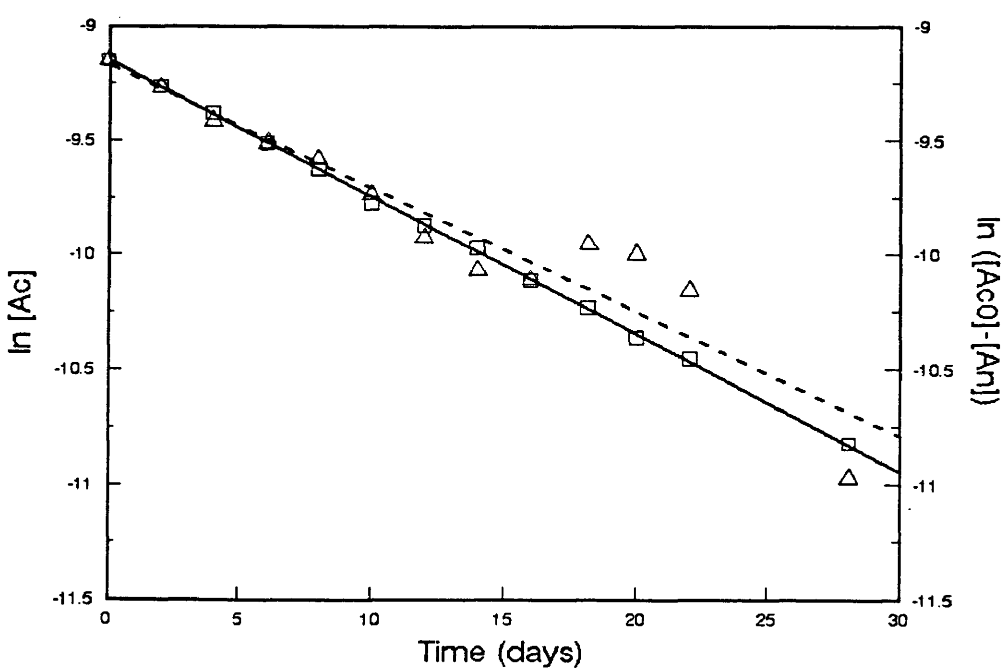
Alkaline Hydrolysis, p-OCH3-acetanilide, replicate 1				
k obs. (disappearance of reactant) = 8.43+/-0.51E-07 sec-1. r = 0.9801, b = -9.269+/-0.066, ssr = 0.183.				
k obs. (appearance of product) = 4.77+/-1.55E-07 sec-1. r = 0.6976, b = -9.453+/-0.174, ssr = 1.03.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.27E-05	-9.2857	0.00E+00	-9.2857
2.00	8.38E-05	-9.3867	1.23E-05	-9.4277
4.00	7.83E-05	-9.4555	2.63E-05	-9.6193
6.08	6.42E-05	-9.6539	3.49E-05	-9.7578
8.00	5.36E-05	-9.8340	4.19E-05	-9.8872
10.00	4.34E-05	-10.0452	4.54E-05	-9.9591
12.00	3.87E-05	-10.1594	5.42E-05	-10.1626
14.00	2.97E-05	-10.4260	4.92E-05	-10.0427
16.00	3.00E-05	-10.4146	5.17E-05	-10.1004
18.17	2.15E-05	-10.7463	4.21E-05	-9.8910
20.00	2.61E-05	-10.5537	7.56E-05	-10.9765
22.00	1.52E-05	-11.0969	3.62E-05	-9.7810
28.08	1.50E-05	-11.1105	9.37E-05	ERR



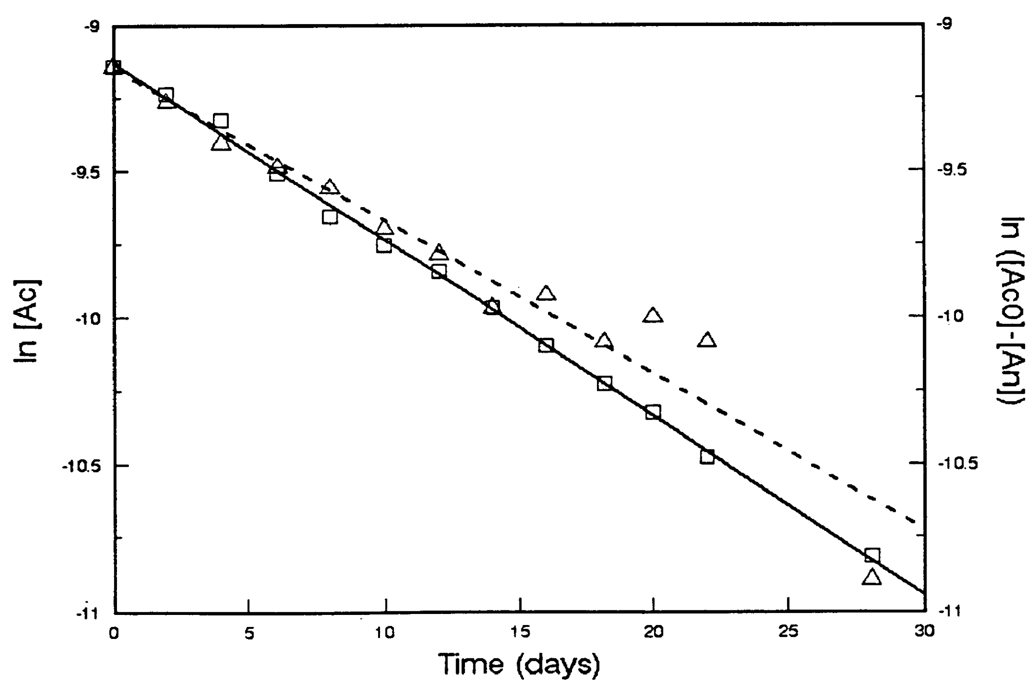
Alkaline Hydrolysis, p-OCH3-acetanilide, replicate 2				
k obs. (disappearance of reactant) = 8.63+/-0.67E-07 sec-1. r = 0.9682, b = -9.282+/-0.086, ssr = 0.312.				
k obs. (appearance of product) = 6.52+/-1.32E-07 sec-1. r = 0.8308, b = -9.160+/-0.168, ssr = 1.20.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	9.96E-05	-9.2147	0.00E+00	-9.2147
2.00	8.84E-05	-9.3335	1.30E-05	-9.3550
4.00	7.69E-05	-9.4736	2.48E-05	-9.5010
6.08	6.16E-05	-9.6949	3.44E-05	-9.6391
8.00	4.89E-05	-9.9266	3.53E-05	-9.6518
10.00	4.82E-05	-9.9412	4.86E-05	-9.8846
12.00	3.37E-05	-10.2970	3.92E-05	-9.7151
14.00	2.44E-05	-10.6226	3.98E-05	-9.7253
16.00	2.82E-05	-10.4753	6.11E-05	-10.1669
18.17	1.85E-05	-10.8977	3.17E-05	-9.5987
20.00	1.90E-05	-10.8721	4.18E-05	-9.7590
22.00	2.11E-05	-10.7668	7.23E-05	-10.5102
28.08	1.50E-05	-11.1092	8.83E-05	-11.3911



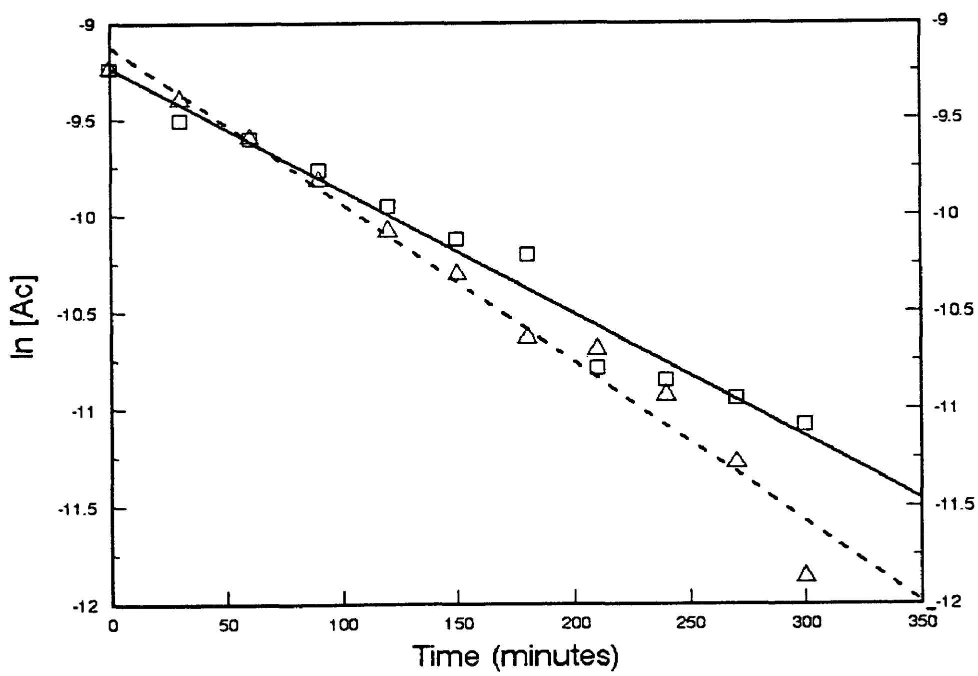
Alkaline Hydrolysis, p-CH3-acetanilide, replicate 1				
k obs. (disappearance of reactant) = 6.92+/-0.05E-07 sec-1. r = 0.9998, b = -9.150+/-0.006, ssr = 0.00161.				
k obs. (appearance of product) = 6.25+/-0.62E-07 sec-1. r = 0.9498, -9.168+/-0.079, ssr = 0.267.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	1.06E-04	-9.1493	0.00E+00	-9.1493
2.00	9.48E-05	-9.2635	1.19E-05	-9.2684
4.00	8.45E-05	-9.3790	2.47E-05	-9.4134
6.08	7.39E-05	-9.5127	3.24E-05	-9.5126
8.00	6.60E-05	-9.6261	3.75E-05	-9.5843
10.00	5.70E-05	-9.7726	4.72E-05	-9.7362
12.00	5.16E-05	-9.8729	5.74E-05	-9.9262
14.00	4.68E-05	-9.9692	6.39E-05	-10.0686
16.00	4.06E-05	-10.1116	6.55E-05	-10.1080
18.17	3.60E-05	-10.2308	5.87E-05	-9.9530
20.00	3.16E-05	-10.3626	6.07E-05	-9.9961
22.00	2.88E-05	-10.4543	6.75E-05	-10.1572
28.08	2.00E-05	-10.8218	8.92E-05	-10.9736



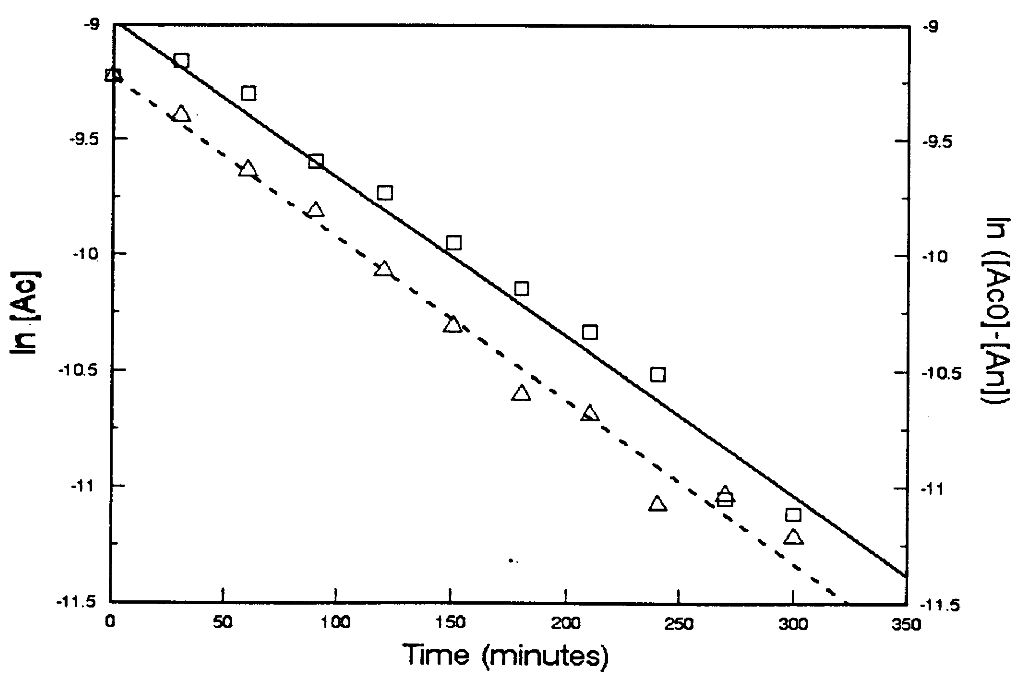
Alkaline Hydrolysis, p-CH3-acetanilide, replicate 2				
k obs. (disappearance of reactant) = 6.99+/-0.09E-07 sec-1. r = 0.9990, b = -9.130+/-0.012, ssr = 0.00574.				
k obs. (appearance of product) = 6.07+/-0.50E-07 sec-1. r = 0.9645, b = -9.146+/-0.064, ssr = 0.174.				
t (days)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.00	1.07E-04	-9.1402	0.00E+00	-9.1402
2.00	9.75E-05	-9.2360	1.25E-05	-9.2641
4.00	8.90E-05	-9.3267	2.49E-05	-9.4040
6.08	7.43E-05	-9.5077	3.16E-05	-9.4886
8.00	6.40E-05	-9.6572	3.67E-05	-9.5596
10.00	5.80E-05	-9.7545	4.58E-05	-9.6976
12.00	5.31E-05	-9.8428	5.09E-05	-9.7841
14.00	4.68E-05	-9.9705	6.04E-05	-9.9677
16.00	4.11E-05	-10.0992	5.84E-05	-9.9261
18.17	3.62E-05	-10.2270	6.56E-05	-10.0865
20.00	3.28E-05	-10.3250	6.20E-05	-10.0020
22.00	2.81E-05	-10.4797	6.56E-05	-10.0865
28.08	2.01E-05	-10.8136	8.87E-05	-10.8939



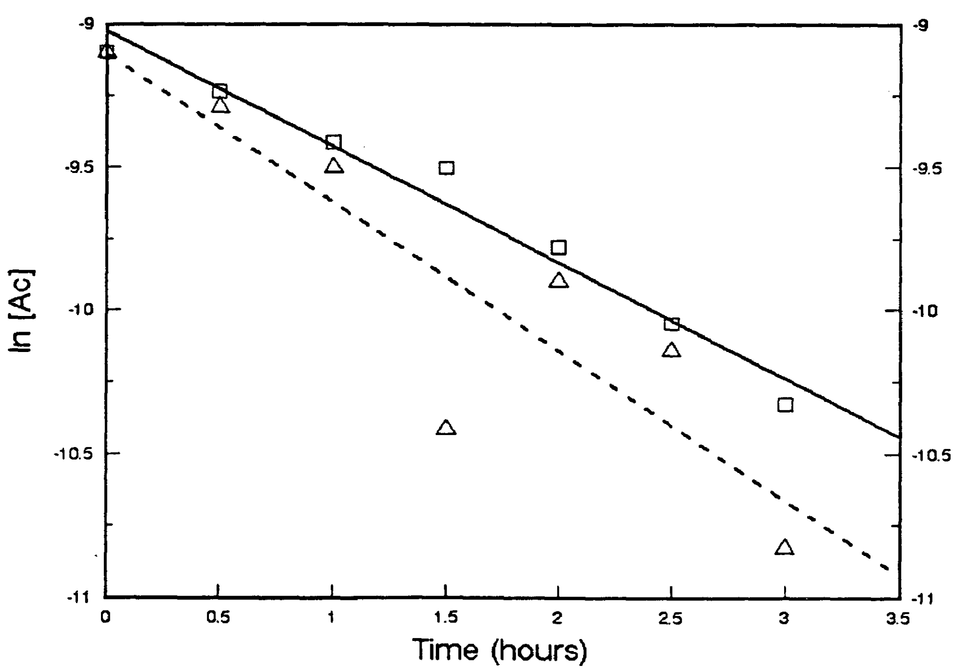
Alkaline Hydrolysis, p-NO2-acetanilide, replicate 1				
k obs. (disappearance of reactant) = 1.06+/-0.06E-04 sec-1. r = 0.9869, b = -9.231+/-0.061, ssr = 0.107.				
k obs. (appearance of product) = 1.36+/-0.07E-04 sec-1. r = 0.9887, b = -9.121+/-0.073, ssr = 0.152.				
t (min.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.74E-05	-9.2372	0.00E+00	-9.2372
30.0	7.43E-05	-9.5073	1.42E-05	-9.3948
60.0	6.77E-05	-9.6007	2.93E-05	-9.5946
90.0	5.76E-05	-9.7613	4.29E-05	-9.8176
120.0	4.76E-05	-9.9531	5.54E-05	-10.0780
150.0	4.02E-05	-10.1210	6.37E-05	-10.2999
180.0	3.72E-05	-10.1995	7.32E-05	-10.6314
210.0	2.07E-05	-10.7873	7.46E-05	-10.6926
240.0	1.94E-05	-10.8490	7.94E-05	-10.9294
270.0	1.77E-05	-10.9413	8.47E-05	-11.2785
300.0	1.54E-05	-11.0799	9.03E-05	-11.8644



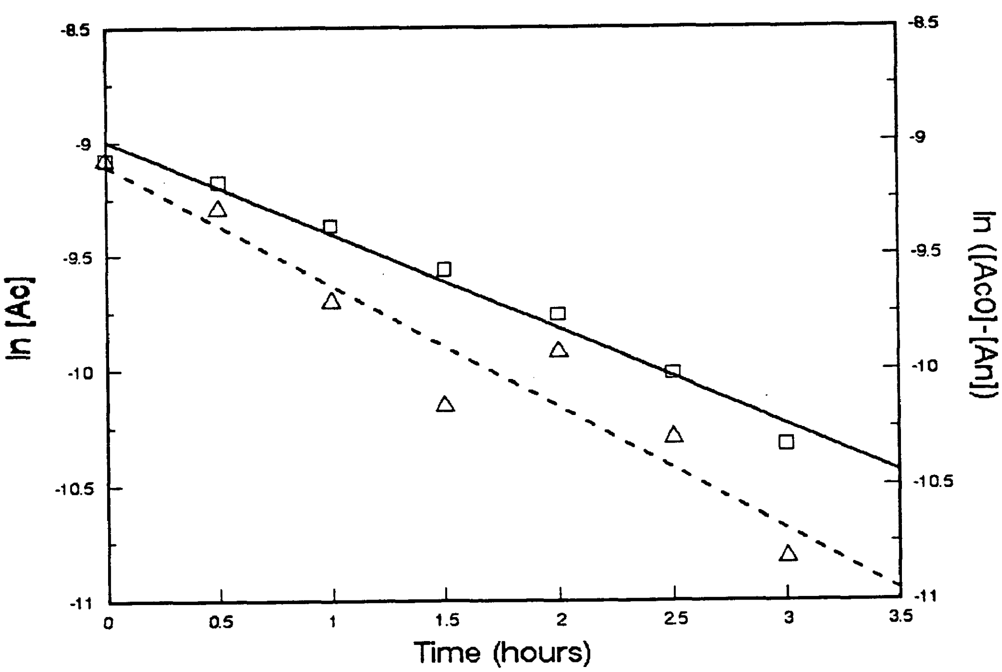
Alkaline Hydrolysis, p-NO2-acetanilide, replicate 2				
k obs. (disappearance of reactant) = 1.14+/-0.07E-04 sec-1. r = 0.9835, b = -8.984, ssr = 0.157.				
k obs. (appearance of product) = 1.17+/-0.05E-04 sec-1. r = 0.9933, b = -9.227+/-0.48, ssr = 0.0663.				
t (min.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.86E-05	-9.2240	0.00E+00	-9.2240
30.0	1.05E-04	-9.1589	1.56E-05	-9.3960
60.0	9.14E-05	-9.3001	3.32E-05	-9.6348
90.0	6.81E-05	-9.5945	4.38E-05	-9.8119
120.0	5.94E-05	-9.7316	5.62E-05	-10.0680
150.0	4.80E-05	-9.9445	6.53E-05	-10.3085
180.0	3.92E-05	-10.1477	7.38E-05	-10.6045
210.0	3.26E-05	-10.3320	7.59E-05	-10.6902
240.0	2.71E-05	-10.5150	8.32E-05	-11.0785
270.0	1.59E-05	-11.0515	8.25E-05	-11.0363
300.0	1.48E-05	-11.1182	8.52E-05	-11.2187



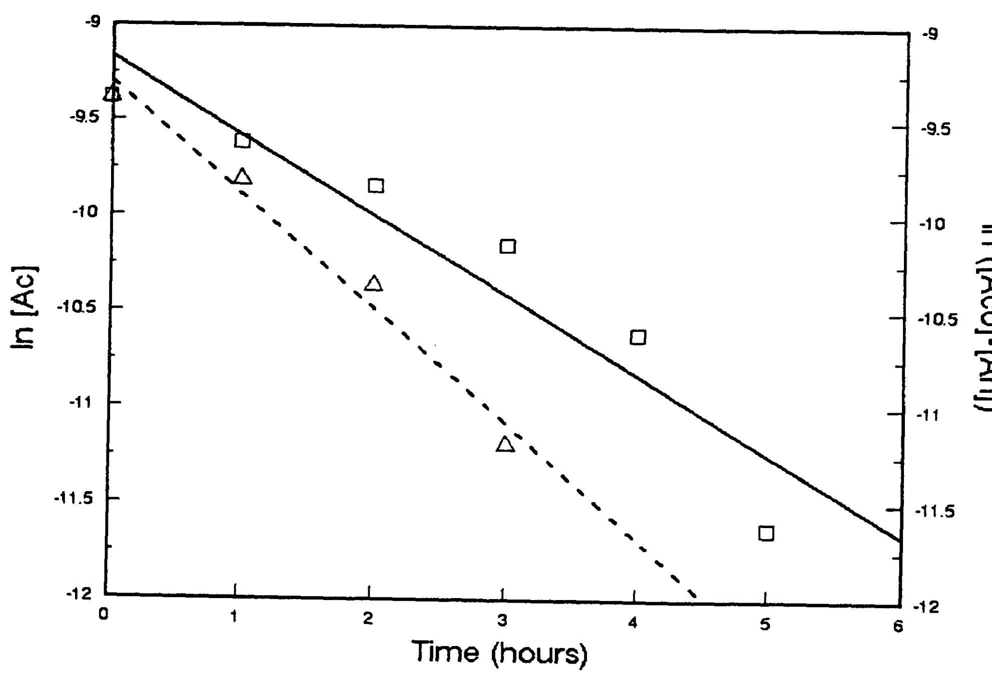
Bacterial Biolysis, Arthrobacter (CSMNS), acetanilide, replicate 1				
k obs. (disappearance of reactant) = 1.13+/-0.09 x 10E-04 sec-1. r = 0.9857, b = -9.022+/-0.056, ssr = 0.0335.				
k obs. (appearance of product) = 1.45+/-0.32 x 10E-04 sec-1. r = 0.8972, b = -9.102+/-0.207, ssr = 0.459.				
t (hours)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.12E-04	-9.0997	0.00E+00	-9.0997
0.5	9.74E-05	-9.2365	1.93E-05	-9.2896
1.0	8.14E-05	-9.4157	3.70E-05	-9.5019
1.5	7.46E-05	-9.5034	8.18E-05	-10.4163
2.0	5.66E-05	-9.7797	6.15E-05	-9.8996
2.5	4.33E-05	-10.0464	7.23E-05	-10.1415
3.0	3.27E-05	-10.3285	9.19E-05	-10.8280



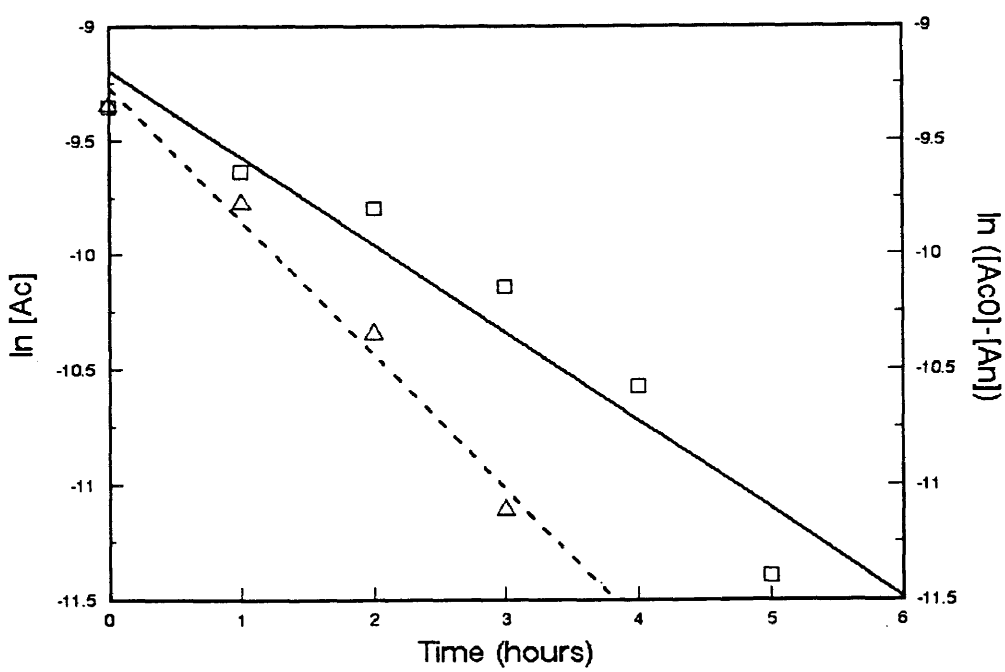
Bacterial Biolysis, Arthrobacter (CSMNS), acetanilide, replicate 2				
k obs. (disappearance of reactant) = 1.15+/-0.07 x 10E-04 sec-1. r = 0.9897, b = -8.992+/-0.048, ssr = 0.0249.				
k obs. (appearance of product) = 1.47+/-0.19 x 10E-04 sec-1. r = 0.9597, b = -9.101+/-0.125, ssr = 0.168.				
t (hours)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.14E-04	-9.0822	0.00E+00	-9.0822
0.5	1.03E-04	-9.1782	2.20E-05	-9.2978
1.0	8.53E-05	-9.3691	5.25E-05	-9.7026
1.5	7.04E-05	-9.5619	7.48E-05	-10.1563
2.0	5.79E-05	-9.7568	6.45E-05	-9.9208
2.5	4.48E-05	-10.0137	7.99E-05	-10.2958
3.0	3.28E-05	-10.3246	9.36E-05	-10.8165



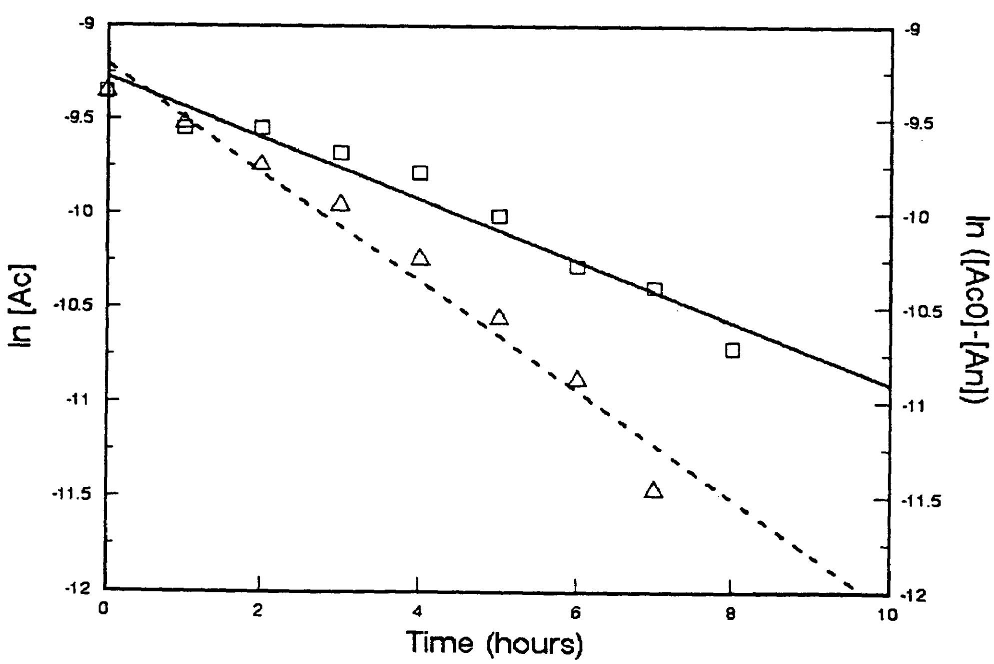
Bacterial Biolysis, Arthrobacter (CSMNS), p-Br-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.16+/-0.19 x 10E-04 sec-1. r = 0.9487, b = -9.165+/-0.210, ssr = 0.336.				
k obs. (appearance of product) = 1.66+/-0.18 x 10E-04 sec-1. r = 0.9888, b = -9.291+/-0.119, ssr = 0.0407.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.42E-05	-9.3818	0.00E+00	-9.3818
1.0	6.69E-05	-9.6128	2.95E-05	-9.8136
2.0	5.33E-05	-9.8393	5.27E-05	-10.3630
3.0	3.91E-05	-10.1500	7.05E-05	-11.1916
4.0	2.45E-05	-10.6163	8.67E-05	ERR
5.0	8.89E-06	-11.6311	9.96E-05	ERR



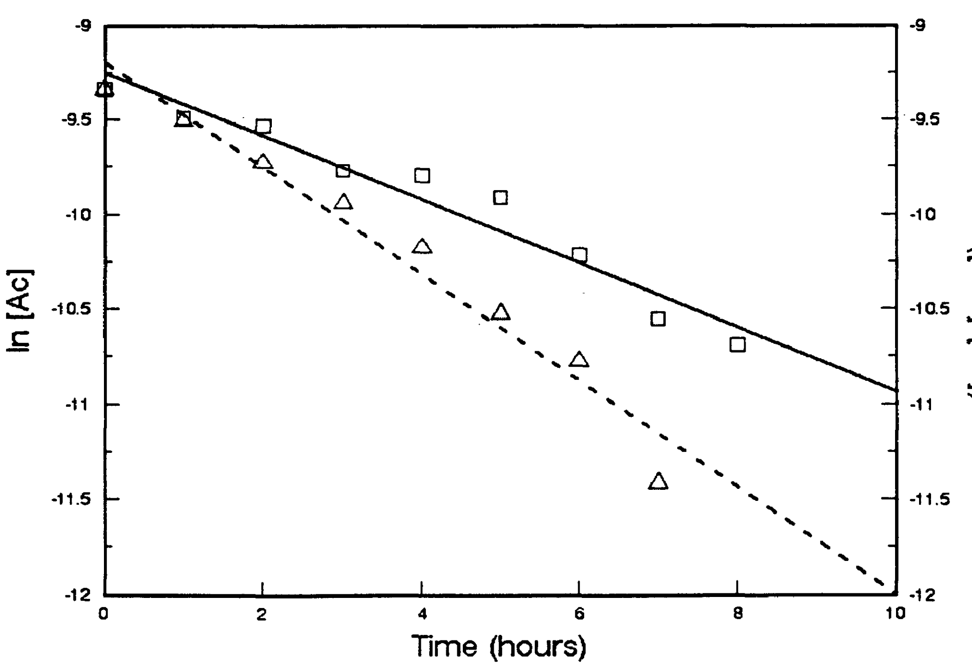
Bacterial Biolysis, Arthrobacter (CSMNS), p-Br-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.06+/-0.15 x 10E-04 sec-1. r = 0.9629, b = -9.195+/-0.162, ssr = 0.200.				
k obs. (appearance of product) = 1.62+/-0.15 x 10E-04 sec-1. r = 0.9916, b = -9.268+/-0.101, ssr = 0.0291.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.69E-05	-9.3502	0.00E+00	-9.3502
1.0	6.51E-05	-9.6390	3.02E-05	-9.7765
2.0	5.56E-05	-9.7981	5.48E-05	-10.3439
3.0	3.95E-05	-10.1394	7.20E-05	-11.1104
4.0	2.56E-05	-10.5734	8.81E-05	ERR
5.0	1.13E-05	-11.3939	9.84E-05	ERR



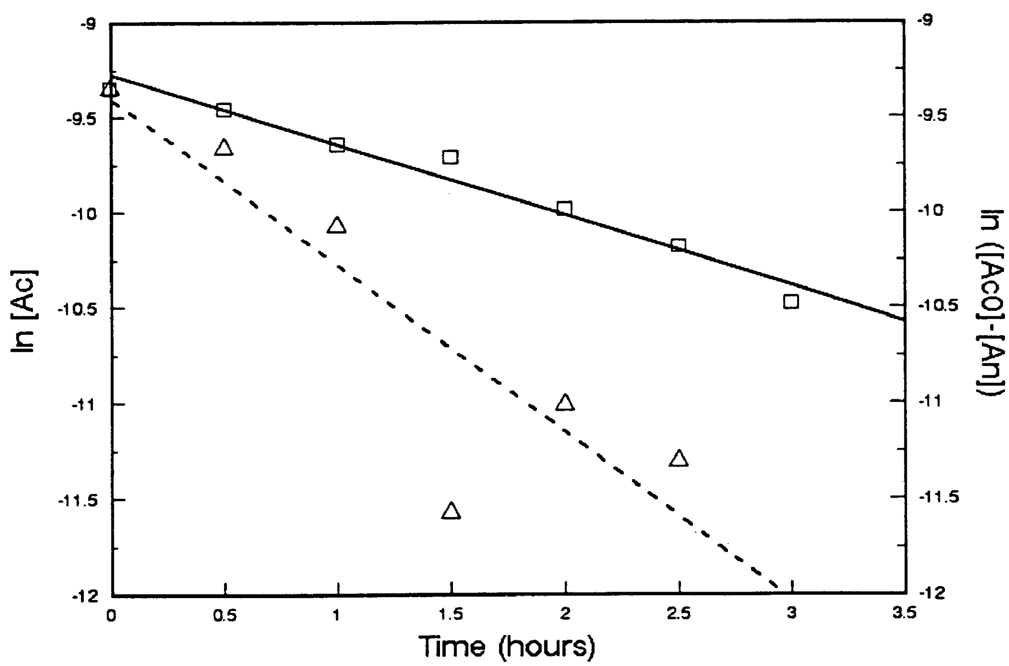
Bacterial Biolysis, Arthrobacter (CSMNS), p-CN-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 4.53+/-0.37 x 10E-05 sec-1. r = 0.9776, b = -9.272+/-0.063, ssr = 0.0740.				
k obs. (appearance of product) = 8.03+/-0.60 x 10E-05 sec-1. r = 0.9834, b = -9.204+/-0.091, ssr = 0.119.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.67E-05	-9.3532	0.00E+00	-9.3532
1.0	7.14E-05	-9.5475	1.38E-05	-9.5263
2.0	7.12E-05	-9.5494	2.81E-05	-9.7451
3.0	6.23E-05	-9.6834	3.93E-05	-9.9573
4.0	5.63E-05	-9.7843	5.10E-05	-10.2419
5.0	4.48E-05	-10.0125	6.07E-05	-10.5597
6.0	3.42E-05	-10.2823	6.79E-05	-10.8815
7.0	3.06E-05	-10.3937	7.62E-05	-11.4645
8.0	2.22E-05	-10.7172	8.55E-05	-13.6218



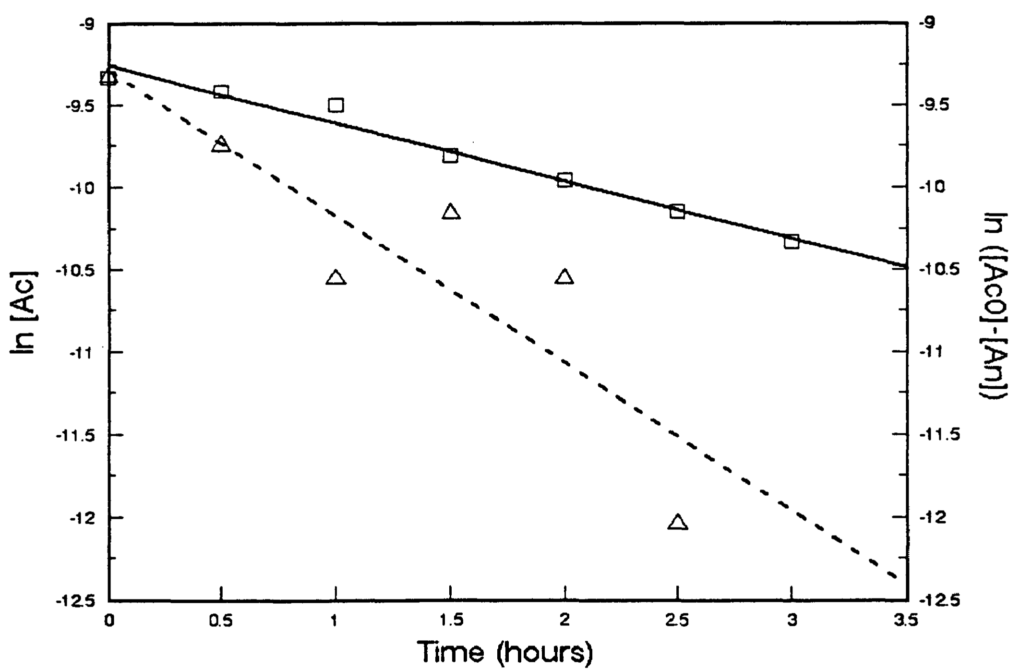
Bacterial Biolysis, Arthrobacter (CSMNS), p-CN-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 7.77+/-0.64 x 10E-05 sec-1. r = 0.9804, b = -9.198+/-0.096, ssr = 0.133.				
k obs. (appearance of product) = 4.67+/-0.41 x 10E-05 sec-1. r = 0.9743, b = -9.250+/-0.070, ssr = 0.0908.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.78E-05	-9.3401	0.00E+00	-9.3401
1.0	7.54E-05	-9.4923	1.37E-05	-9.5091
2.0	7.25E-05	-9.5316	2.83E-05	-9.7299
3.0	5.70E-05	-9.7719	3.98E-05	-9.9428
4.0	5.56E-05	-9.7973	4.98E-05	-10.1775
5.0	4.95E-05	-9.9136	6.10E-05	-10.5252
6.0	3.66E-05	-10.2147	6.70E-05	-10.7789
7.0	2.61E-05	-10.5522	7.68E-05	-11.4163
8.0	2.27E-05	-10.6910	8.54E-05	-12.9083



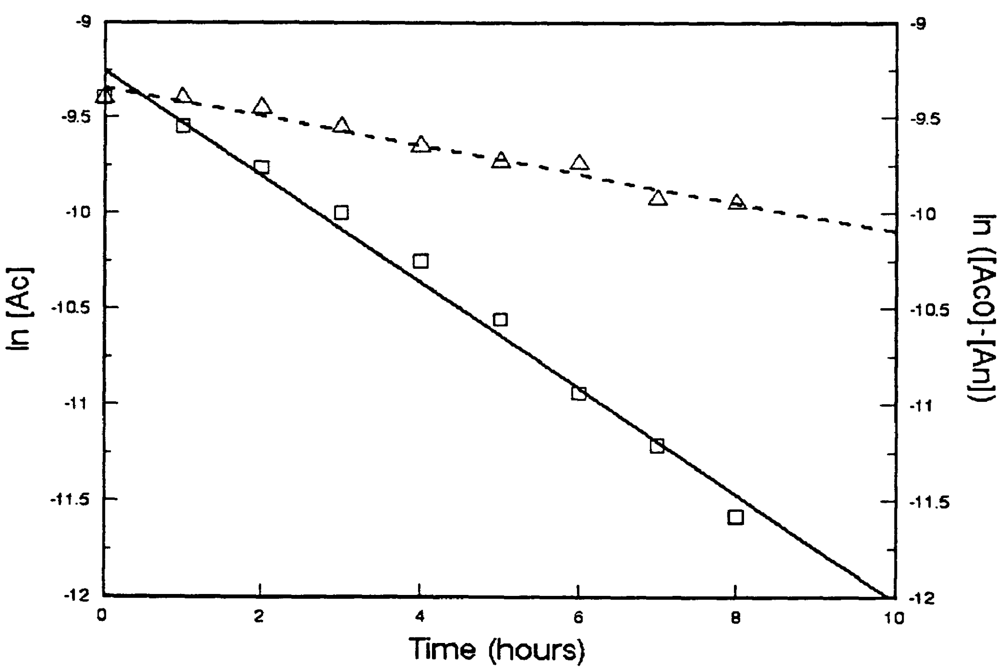
Bacterial Biolysis, Arthrobacter (CSMNS), p-F-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.03+/-0.08 x 10E-04 sec-1. r = 0.9849, b = -9.274+/-0.052, ssr = 0.0297.				
k obs. (appearance of product) = 2.43+/-0.63 x 10E-04 sec-1. r = 0.8868, b = -9.400+/-0.345, ssr = 0.911.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.72E-05	-9.3474	0.00E+00	-9.3474
0.5	7.80E-05	-9.4587	2.36E-05	-9.6632
1.0	6.50E-05	-9.6417	4.50E-05	-10.0739
1.5	6.06E-05	-9.7117	7.78E-05	-11.5718
2.0	4.61E-05	-9.9842	7.07E-05	-11.0112
2.5	3.79E-05	-10.1804	7.49E-05	-11.3047
3.0	2.81E-05	-10.4803	8.66E-05	-14.4167



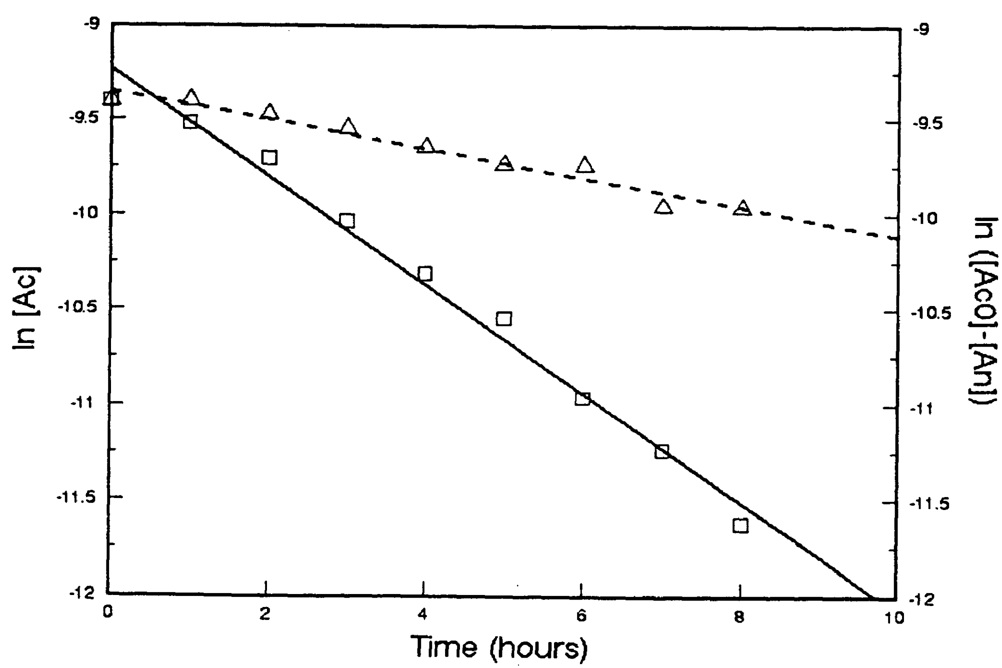
Bacterial Biolysis, Arthrobacter (CSMNS), p-F-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 9.78+/-0.64 x 10E-05 sec-1. r = 0.9895, b = -9.258+/-0.414, ssr = 0.0184.				
k obs. (appearance of product) = 2.48+/-0.63 x 10E-04 sec-1. r = 0.8912, b = -9.285+/-0.343, ssr = 0.900.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.87E-05	-9.3307	0.00E+00	-9.3307
0.5	8.13E-05	-9.4169	3.01E-05	-9.7453
1.0	7.48E-05	-9.5006	6.27E-05	-10.5581
1.5	5.50E-05	-9.8079	5.01E-05	-10.1620
2.0	4.72E-05	-9.9621	6.27E-05	-10.5572
2.5	3.91E-05	-10.1486	8.28E-05	-12.0423
3.0	3.26E-05	-10.3313	9.85E-05	ERR



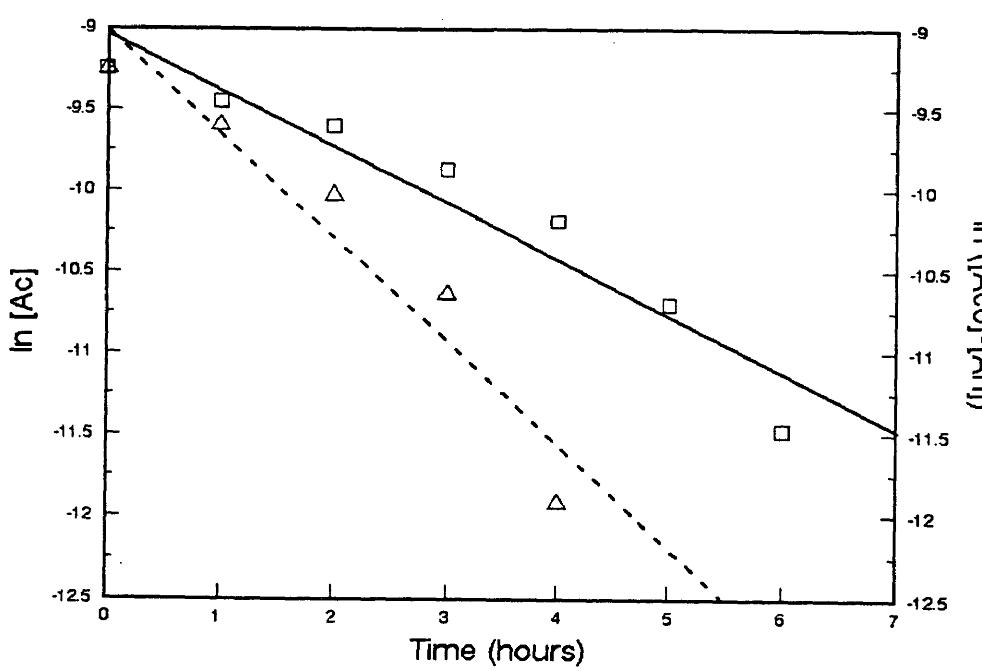
Bacterial Biolysis, Arthrobacter (CSMNS), p-OCH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 7.70+/-0.34 x 10E-05 sec-1. r = 0.9932, b = -9.251+/-0.058, ssr = 0.0633.				
k obs. (appearance of product) = 2.10+/-0.15 x 10E-05 sec-1. r = 0.9833, b = -9.341+/-0.025, ssr = 0.0119.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.29E-05	-9.3980	0.00E+00	-9.3980
1.0	7.13E-05	-9.5481	0.00E+00	-9.3980
2.0	5.76E-05	-9.7623	4.10E-06	-9.4488
3.0	4.55E-05	-9.9968	1.17E-05	-9.5506
4.0	3.53E-05	-10.2504	1.84E-05	-9.6487
5.0	2.60E-05	-10.5567	2.35E-05	-9.7310
6.0	1.77E-05	-10.9401	2.41E-05	-9.7408
7.0	1.35E-05	-11.2120	3.40E-05	-9.9252
8.0	9.34E-06	-11.5810	3.49E-05	-9.9448



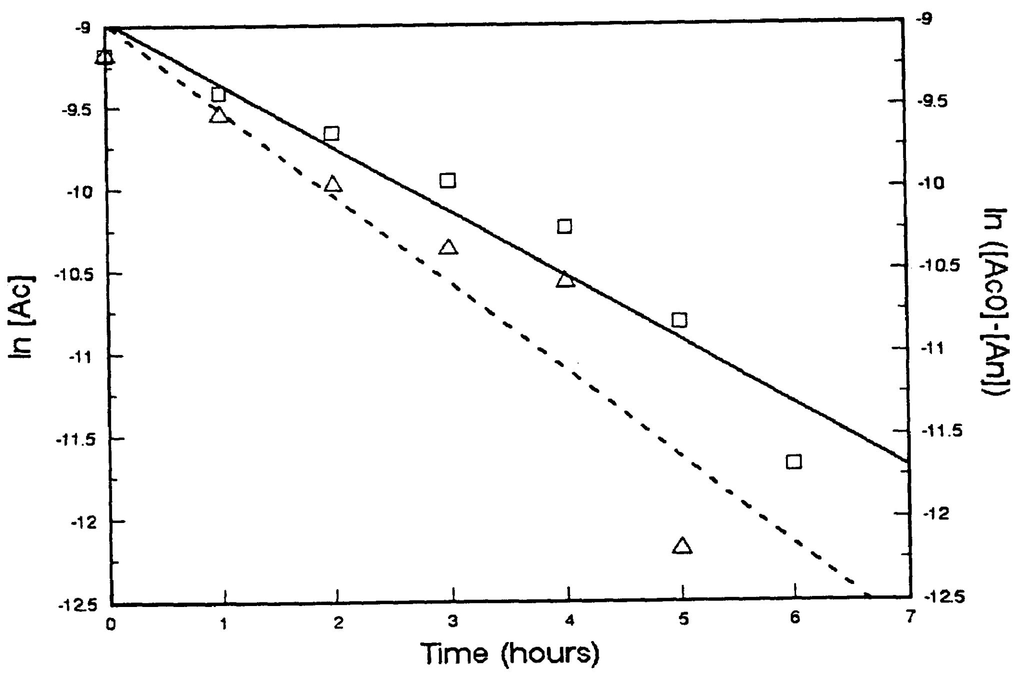
Bacterial Biolysis, Arthrobacter (CSMNS), p-OCH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 7.91+/-0.36 x 10E-05 sec-1. r = 0.9928, b = -9.233+/-0.062, ssr = 0.0707.				
k obs. (appearance of product) = 2.14+/-0.17 x 10E-05 sec-1. r = 0.9797, b = -9.344+/-0.028, ssr = 0.0149.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.25E-05	-9.4028	0.00E+00	-9.4028
1.0	7.35E-05	-9.5176	0.00E+00	-9.4028
2.0	6.10E-05	-9.7052	5.76E-06	-9.4751
3.0	4.38E-05	-10.0355	1.11E-05	-9.5477
4.0	3.32E-05	-10.3122	1.78E-05	-9.6454
5.0	2.63E-05	-10.5465	2.35E-05	-9.7384
6.0	1.73E-05	-10.9655	2.37E-05	-9.7409
7.0	1.31E-05	-11.2393	3.51E-05	-9.9566
8.0	8.93E-06	-11.6262	3.54E-05	-9.9638



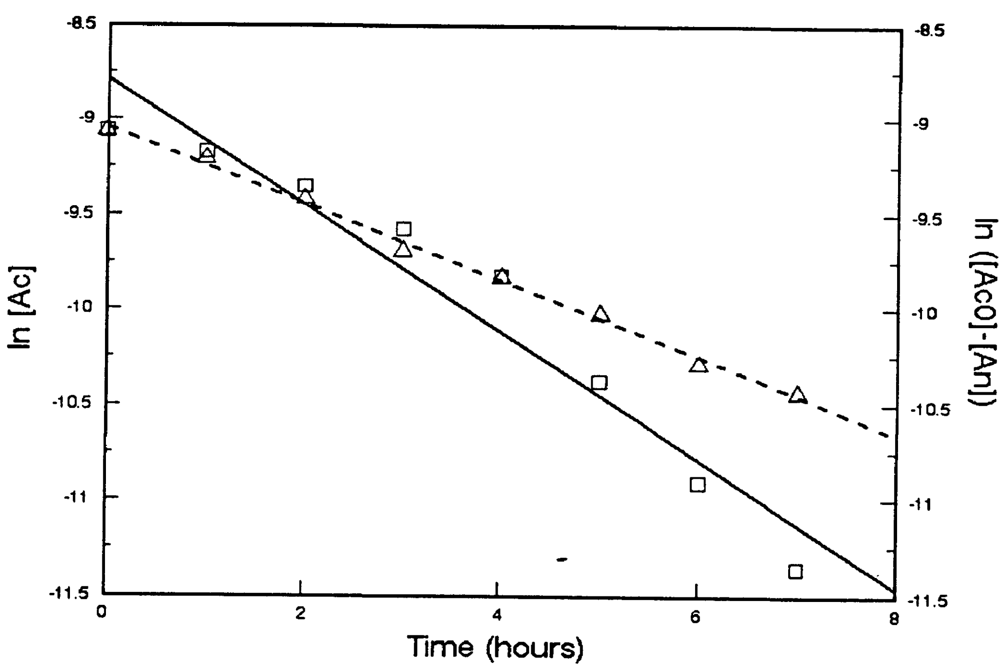
Bacterial Biolysis, Arthrobacter (CSMNS), p-CH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.08+/-0.13 x 10E-04 sec-1. r = 0.9633, b = -8.970+/-0.175, ssr = 0.329.				
k obs. (appearance of product) = 1.47+/-0.27 x 10E-05 sec-1. r = 0.9368, b = -8.983+/-0.299, ssr = 0.683.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.03E-04	-9.1826	0.00E+00	-9.1826
1.0	8.14E-05	-9.4160	3.13E-05	-9.5455
2.0	6.38E-05	-9.6600	5.62E-05	-9.9740
3.0	4.75E-05	-9.9540	7.15E-05	-10.3700
4.0	3.59E-05	-10.2359	7.71E-05	-10.5700
5.0	2.01E-05	-10.8165	9.77E-05	-12.1916
6.0	8.42E-06	-11.6848	1.09E-04	ERR



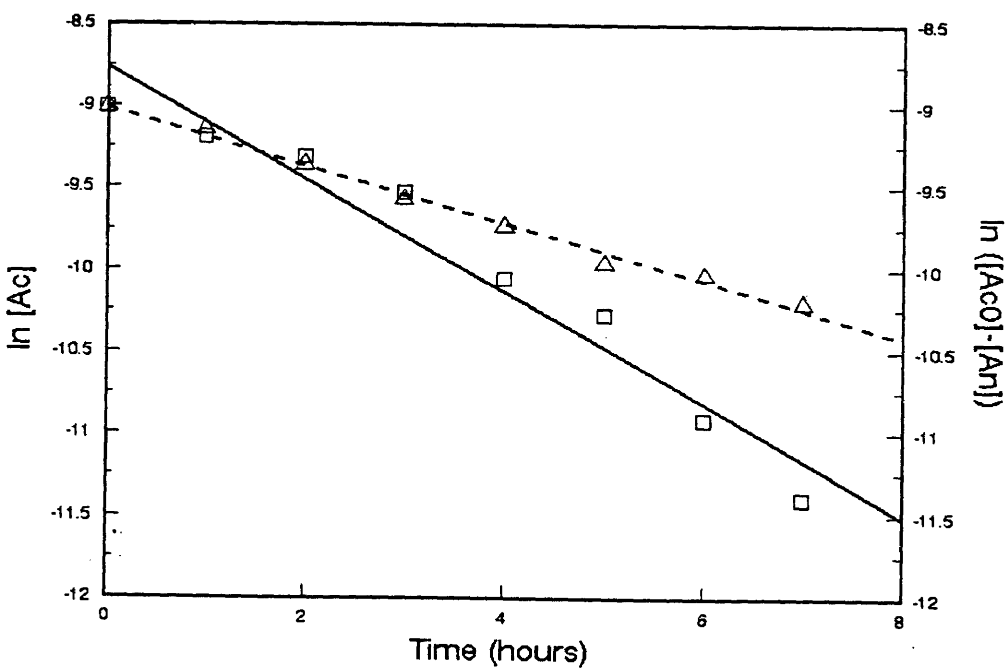
Bacterial Biolysis, Arthrobacter (CSMNS), p-CH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 9.67+/-1.28 x 10E-05 sec-1. r = 0.9591, b = -9.035+/-0.166, ssr = 0.296.				
k obs. (appearance of product) = 1.77+/-0.29 x 10E-04 sec-1. r = 0.9613, b = -9.013+/-0.258, ssr = 0.334.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.61E-05	-9.2503	0.00E+00	-9.2503
1.0	7.82E-05	-9.4568	2.84E-05	-9.6010
2.0	6.73E-05	-9.6065	5.21E-05	-10.0312
3.0	5.15E-05	-9.8732	7.21E-05	-10.6379
4.0	3.75E-05	-10.1911	8.94E-05	-11.9183
5.0	2.25E-05	-10.6998	1.01E-04	ERR
6.0	1.04E-05	-11.4763	9.90E-05	ERR



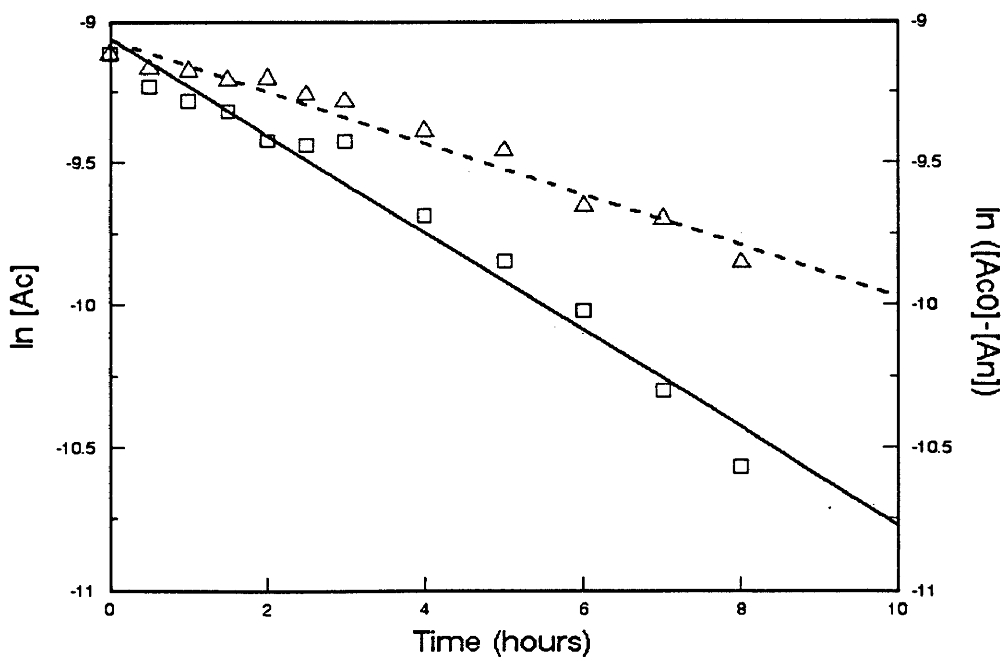
Bacterial Biolysis, Arthrobacter (CSMNS), p-NO2-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 9.29+/-0.95 x 10E-05 sec-1. r = 0.9700, b = -8.784+/-0.143, ssr = 0.295.				
k obs. (appearance of product) = 5.63+/-0.15 x 10E-05 sec-1. r = 0.9980, b = -9.039+/-0.022, ssr = 0.00706.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.16E-04	-9.0627	0.00E+00	-9.0627
1.0	1.04E-04	-9.1697	1.58E-05	-9.2087
2.0	8.66E-05	-9.3544	3.50E-05	-9.4222
3.0	6.92E-05	-9.5792	5.43E-05	-9.6952
4.0	5.39E-05	-9.8278	6.23E-05	-9.8329
5.0	3.11E-05	-10.3792	7.17E-05	-10.0265
6.0	1.83E-05	-10.9082	8.20E-05	-10.2921
7.0	1.16E-05	-11.3606	8.67E-05	-10.4409



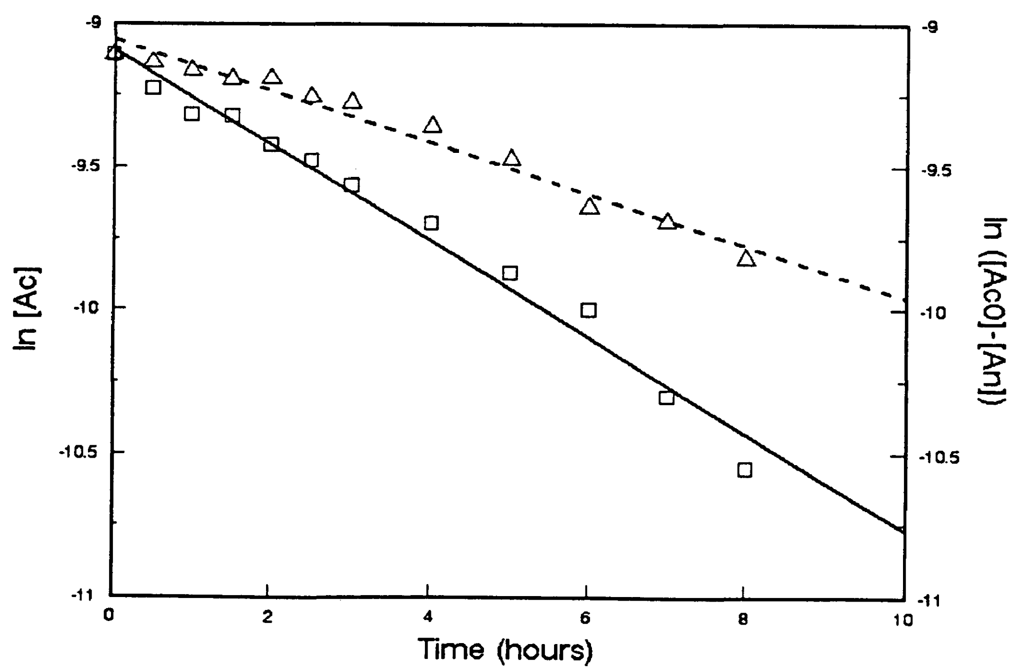
Bacterial Biolysis, Arthrobacter (CSMNS), p-NO2-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 9.53+/-0.90 x 10E-05 sec-1. r = 0.9742, b = -8.762+/-0.136, ssr = 0.265.				
k obs. (appearance of product) = 4.89+/-0.18 x 10E-05 sec-1. r = 0.9961, b = -9.012+/-0.027, ssr = 0.0103.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.22E-04	-9.0086	0.00E+00	-9.0086
1.0	1.02E-04	-9.1910	1.60E-05	-9.1484
2.0	9.02E-05	-9.3130	3.61E-05	-9.3581
3.0	7.26E-05	-9.5304	5.26E-05	-9.5712
4.0	4.29E-05	-10.0560	6.33E-05	-9.7365
5.0	3.42E-05	-10.2822	7.52E-05	-9.9614
6.0	1.81E-05	-10.9203	7.85E-05	-10.0353
7.0	1.12E-05	-11.4013	8.54E-05	-10.2066



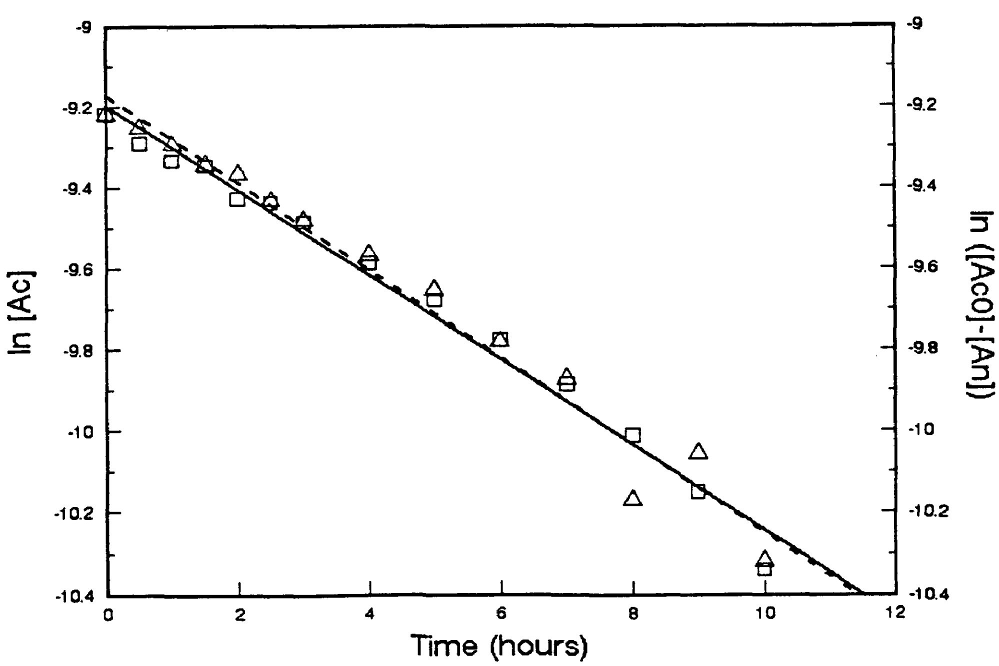
Bacterial Biolysis, Arthrobacter (DSMP), acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 4.75+/-0.27 x 10E-05 sec-1. r = 0.9842, b = -9.062+/-0.041, ssr = 0.0719.				
k obs. (appearance of product) = 2.52+/-0.15 x 10E-05 sec-1. r = 0.9819, b = -9.067+/-0.023, ssr = 0.0232.				
t (hours)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.10E-04	-9.1162	0.00E+00	-9.1162
0.5	9.78E-05	-9.2329	5.58E-06	-9.1683
1.0	9.30E-05	-9.2834	6.48E-06	-9.1770
1.5	8.96E-05	-9.3204	9.71E-06	-9.2087
2.0	8.09E-05	-9.4225	9.12E-06	-9.2028
2.5	7.97E-05	-9.4375	1.49E-05	-9.2623
3.0	8.07E-05	-9.4253	1.71E-05	-9.2854
4.0	6.20E-05	-9.6881	2.61E-05	-9.3871
5.0	5.28E-05	-9.8488	3.19E-05	-9.4590
6.0	4.44E-05	-10.0218	4.58E-05	-9.6548
7.0	3.36E-05	-10.3015	4.86E-05	-9.7008
8.0	2.57E-05	-10.5695	5.73E-05	-9.8540



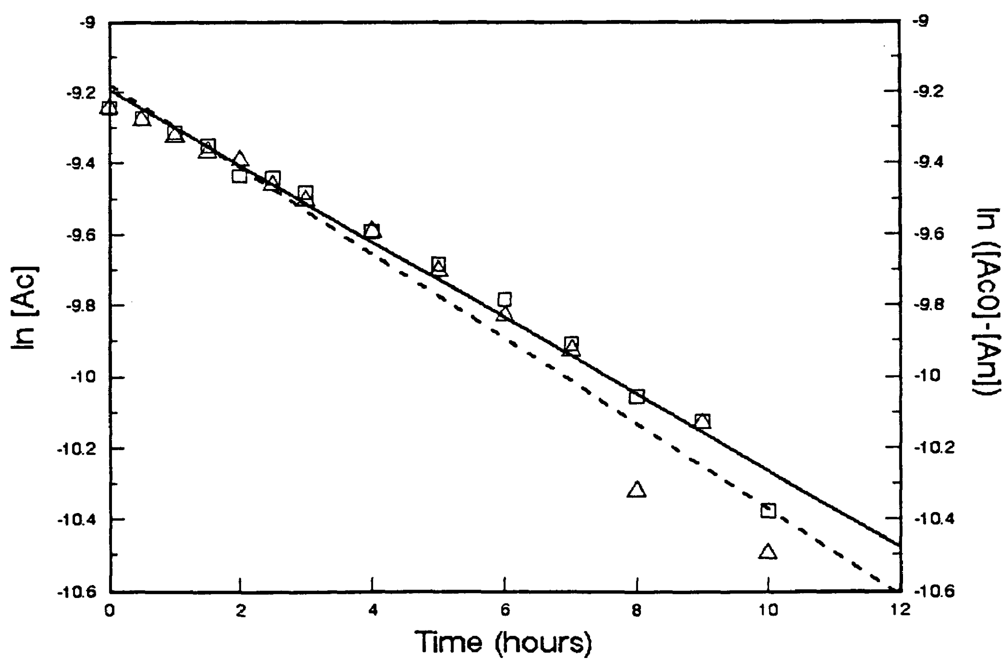
Bacterial Biolysis, Arthrobacter (DSMP), acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 4.67+/-0.20 x 10E-05 sec-1. r = 0.9906, b = -9.089+/-0.031, ssr = 0.0410.				
k obs. (appearance of product) = 2.51+/-0.13 x 10E-05 sec-1. r = 0.9860, b = -9.055+/-0.020, ssr = 0.0178.				
t (hours)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.11E-04	-9.1075	0.00E+00	-9.1075
0.5	9.84E-05	-9.2268	3.40E-06	-9.1387
1.0	8.97E-05	-9.3192	6.29E-06	-9.1659
1.5	8.93E-05	-9.3235	9.29E-06	-9.1951
2.0	8.07E-05	-9.4250	8.95E-06	-9.1918
2.5	7.66E-05	-9.4767	1.53E-05	-9.2564
3.0	7.02E-05	-9.5645	1.73E-05	-9.2775
4.0	6.14E-05	-9.6980	2.47E-05	-9.3594
5.0	5.16E-05	-9.8723	3.39E-05	-9.4726
6.0	4.54E-05	-9.9996	4.59E-05	-9.6415
7.0	3.35E-05	-10.3026	4.90E-05	-9.6919
8.0	2.62E-05	-10.5500	5.65E-05	-9.8203



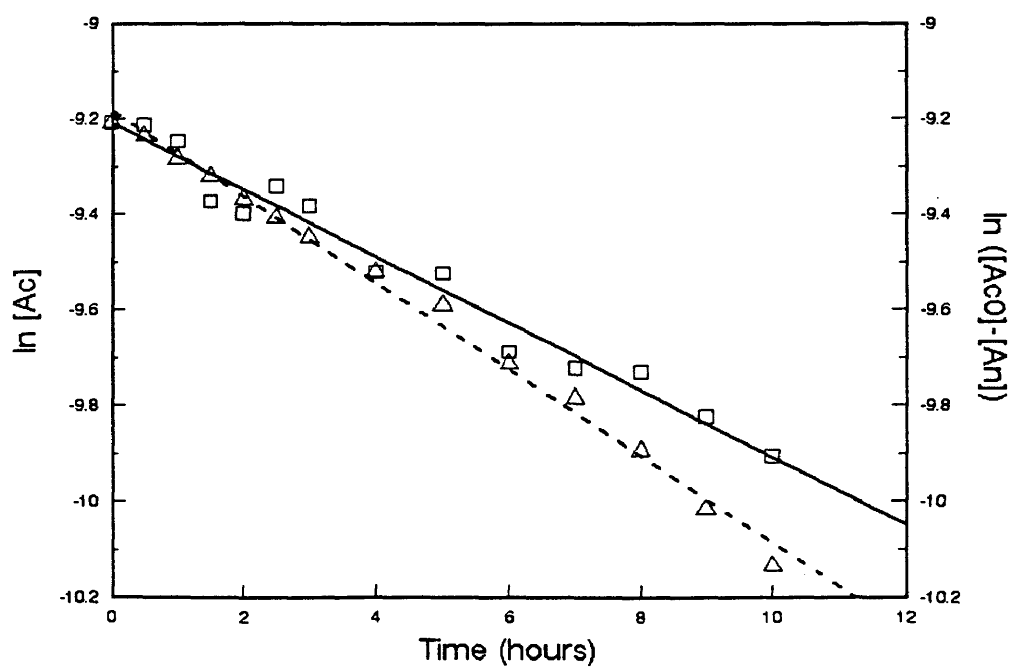
Bacterial Biolysis, Arthrobacter (DSMP), p-Br-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 2.90+/-0.10 x 10E-05 sec-1. r = 0.9930, b = -9.197+/-0.019, ssr = 0.0221.				
k obs. (appearance of product) = 2.99+/-0.14 x 10E-05 sec-1. r = 0.9869, b = -9.174+/-0.027, ssr = 0.0436.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.91E-05	-9.2193	0.00E+00	-9.2193
0.5	9.22E-05	-9.2914	3.40E-06	-9.2541
1.0	8.83E-05	-9.3345	7.33E-06	-9.2961
1.5	8.72E-05	-9.3473	1.18E-05	-9.3456
2.0	8.03E-05	-9.4299	1.37E-05	-9.3680
2.5	7.95E-05	-9.4400	1.91E-05	-9.4337
3.0	7.59E-05	-9.4855	2.30E-05	-9.4827
4.0	6.87E-05	-9.5865	2.91E-05	-9.5670
5.0	6.26E-05	-9.6788	3.50E-05	-9.6547
6.0	5.67E-05	-9.7777	4.26E-05	-9.7819
7.0	5.09E-05	-9.8852	4.76E-05	-9.8737
8.0	4.49E-05	-10.0109	6.09E-05	-10.1712
9.0	3.90E-05	-10.1507	5.62E-05	-10.0571
10.0	3.22E-05	-10.3423	6.62E-05	-10.3208



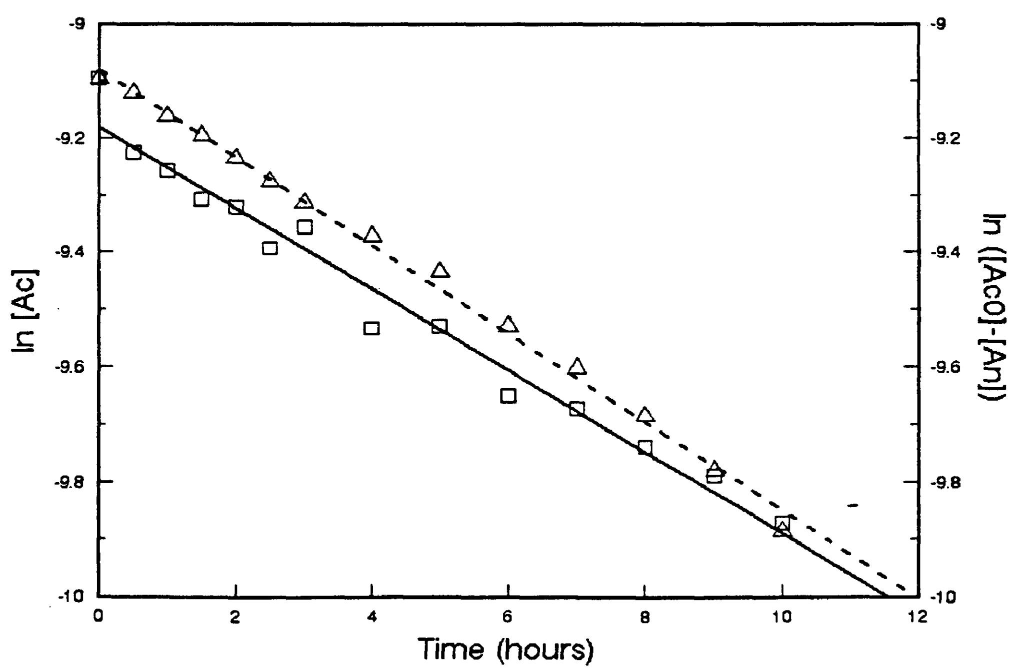
Bacterial Biolysis, Arthrobacter (DSMP), p-Br-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 2.97+/-0.11 x 10E-05 sec-1. r = 0.9920, b = -9.194+/-0.021, ssr = 0.0259.				
k obs. (appearance of product) = 3.32+/-0.21 x 10E-05 sec-1. r = 0.9772, b = -9.177+/-0.040, ssr = 0.0951.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.67E-05	-9.2436	0.00E+00	-9.2436
0.5	9.39E-05	-9.2729	3.44E-06	-9.2798
1.0	9.02E-05	-9.3135	7.79E-06	-9.3275
1.5	8.68E-05	-9.3516	1.14E-05	-9.3695
2.0	7.97E-05	-9.4375	1.34E-05	-9.3922
2.5	7.93E-05	-9.4423	1.90E-05	-9.4621
3.0	7.62E-05	-9.4821	2.23E-05	-9.5058
4.0	6.82E-05	-9.5935	2.86E-05	-9.5934
5.0	6.22E-05	-9.6854	3.57E-05	-9.7039
6.0	5.63E-05	-9.7846	4.30E-05	-9.8316
7.0	4.97E-05	-9.9093	4.79E-05	-9.9280
8.0	4.28E-05	-10.0581	6.38E-05	-10.3219
9.0	4.00E-05	-10.1270	5.69E-05	-10.1313
10.0	3.11E-05	-10.3772	6.91E-05	-10.4974



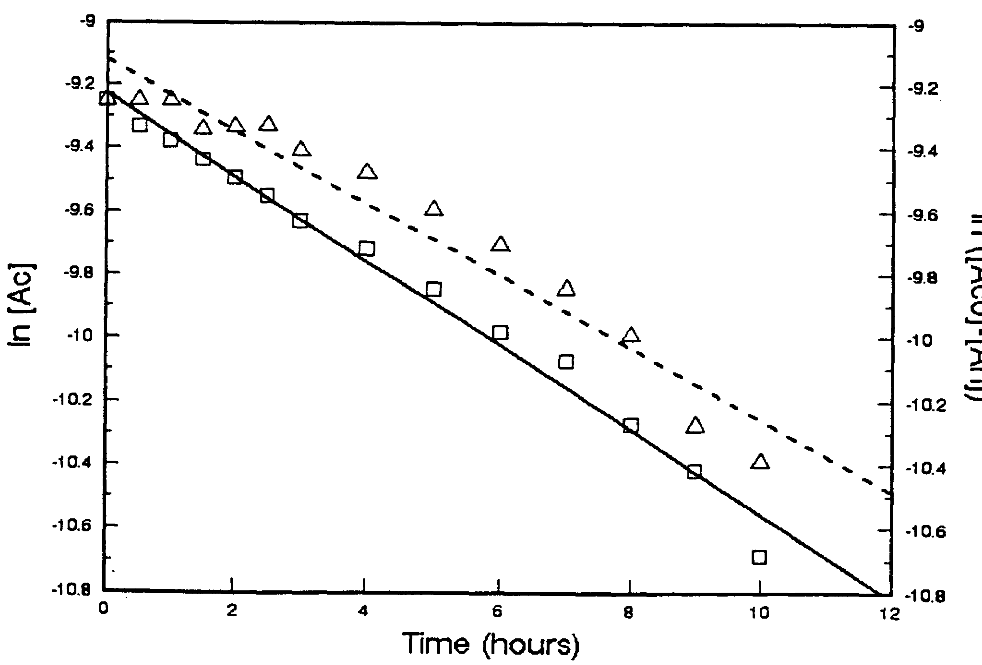
Bacterial Biolysis, Arthrobacter (DSMP), p-CN-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.94+/-0.09 x 10E-05 sec-1. r = 0.9865, b = -9.209+/-0.018, ssr = 0.0192.				
k obs. (appearance of product) = 2.52+/-0.06 x 10E-05 sec-1. r = 0.9969, b = -9.181+/-0.011, ssr = 0.00725.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.00E-04	-9.2069	0.00E+00	-9.2069
0.5	9.98E-05	-9.2121	2.84E-06	-9.2356
1.0	9.64E-05	-9.2471	7.40E-06	-9.2836
1.5	8.50E-05	-9.3732	1.08E-05	-9.3205
2.0	8.27E-05	-9.3999	1.50E-05	-9.3684
2.5	8.77E-05	-9.3411	1.83E-05	-9.4078
3.0	8.41E-05	-9.3836	2.15E-05	-9.4485
4.0	7.33E-05	-9.5213	2.70E-05	-9.5208
5.0	7.31E-05	-9.5241	3.20E-05	-9.5912
6.0	6.20E-05	-9.6882	3.98E-05	-9.7129
7.0	5.99E-05	-9.7227	4.40E-05	-9.7848
8.0	5.94E-05	-9.7311	4.99E-05	-9.8952
9.0	5.41E-05	-9.8244	5.57E-05	-10.0174
10.0	4.98E-05	-9.9071	6.07E-05	-10.1352



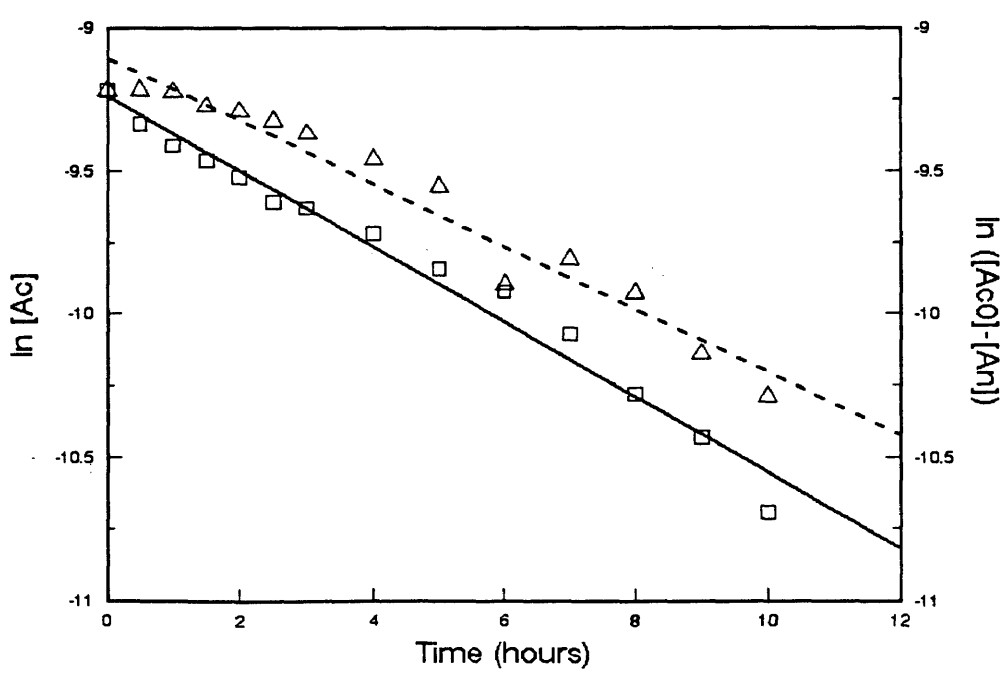
Bacterial Biolysis, Arthrobacter (DSMP), p-CN-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.97+/-0.09 x 10E-05 sec-1. r = 0.9873, b = -9.180+/-0.017, ssr = 0.0183.				
k obs. (appearance of product) = 2.14+/-0.04 x 10E-05 sec-1. r = 0.9981, b = -9.079+/-0.007, ssr = 0.00346.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.12E-04	-9.0962	0.00E+00	-9.0962
0.5	9.85E-05	-9.2250	2.82E-06	-9.1216
1.0	9.54E-05	-9.2574	7.13E-06	-9.1619
1.5	9.08E-05	-9.3067	1.06E-05	-9.1953
2.0	8.94E-05	-9.3222	1.46E-05	-9.2354
2.5	8.33E-05	-9.3934	1.85E-05	-9.2765
3.0	8.65E-05	-9.3551	2.19E-05	-9.3130
4.0	7.25E-05	-9.5324	2.69E-05	-9.3711
5.0	7.27E-05	-9.5289	3.22E-05	-9.4346
6.0	6.44E-05	-9.6509	3.94E-05	-9.5286
7.0	6.29E-05	-9.6738	4.45E-05	-9.6018
8.0	5.89E-05	-9.7394	4.99E-05	-9.6857
9.0	5.60E-05	-9.7896	5.55E-05	-9.7802
10.0	5.16E-05	-9.8710	6.12E-05	-9.8862



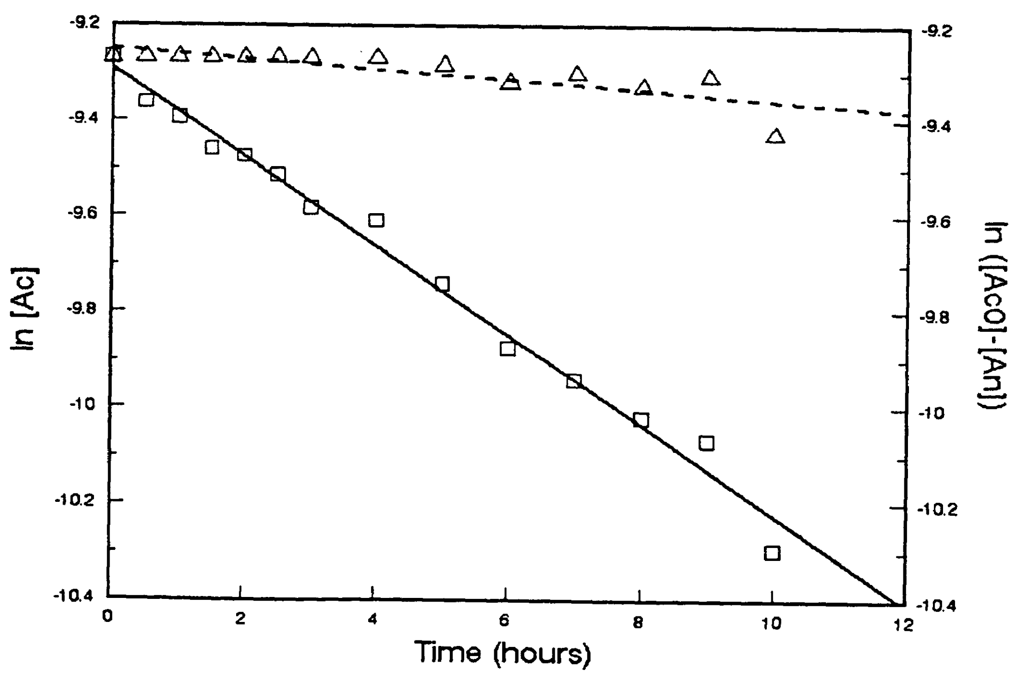
Bacterial Biolysis, Arthrobacter (DSMP), p-F-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 3.69+/-0.12 x 10E-05 sec-1. r = 0.9936, b = -9.226+/-0.023, ssr = 0.0323.				
k obs. (appearance of product) = 3.17+/-0.22 x 10E-05 sec-1. r = 0.9731, b = -9.119+/-0.041, ssr = 0.103.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.61E-05	-9.2504	0.00E+00	-9.2504
0.5	8.86E-05	-9.3315	0.00E+00	-9.2504
1.0	8.47E-05	-9.3768	0.00E+00	-9.2504
1.5	7.96E-05	-9.4380	8.55E-06	-9.3436
2.0	7.53E-05	-9.4943	7.80E-06	-9.3350
2.5	7.11E-05	-9.5509	7.44E-06	-9.3310
3.0	6.56E-05	-9.6318	1.40E-05	-9.4079
4.0	6.03E-05	-9.7169	1.97E-05	-9.4799
5.0	5.30E-05	-9.8454	2.80E-05	-9.5955
6.0	4.62E-05	-9.9818	3.51E-05	-9.7054
7.0	4.21E-05	-10.0745	4.31E-05	-9.8454
8.0	3.46E-05	-10.2712	5.03E-05	-9.9928
9.0	2.99E-05	-10.4169	6.16E-05	-10.2759
10.0	2.29E-05	-10.6858	6.53E-05	-10.3902



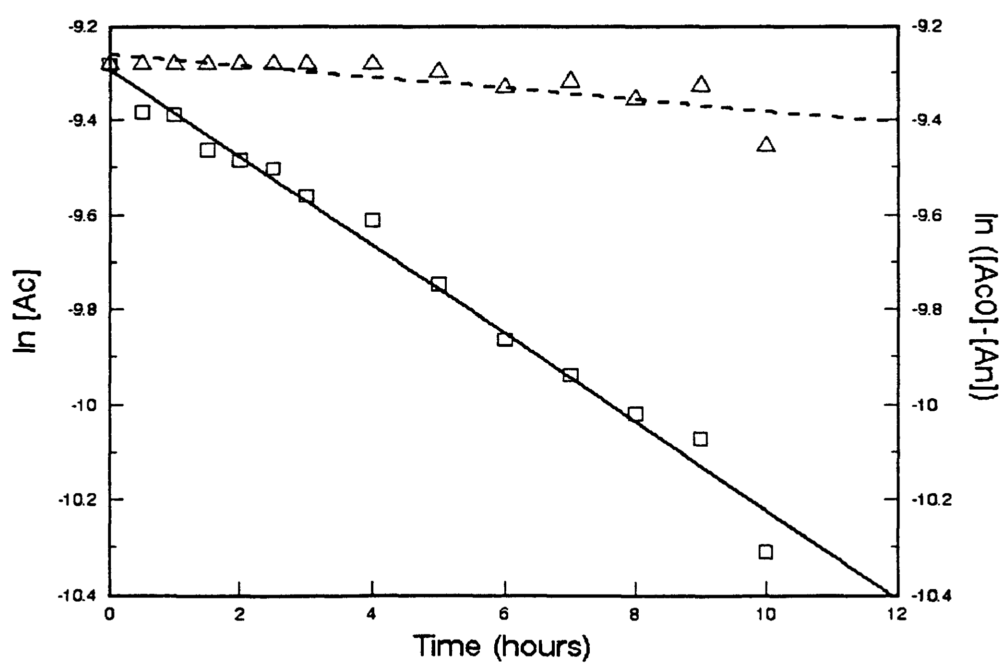
Bacterial Biolysis, Arthrobacter (DSMP), p-F-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 3.65+/-0.15 x 10E-05 sec-1. r = 0.9901, b = -9.238+/-0.029, ssr = 0.0490.				
k obs. (appearance of product) = 3.06+/-0.19 x 10E-05 sec-1. r = 0.9786, b = -9.104+/-0.035, ssr = 0.0755.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.93E-05	-9.2175	0.00E+00	-9.2175
0.5	8.83E-05	-9.3351	0.00E+00	-9.2175
1.0	8.17E-05	-9.4122	7.95E-07	-9.2256
1.5	7.76E-05	-9.4645	5.54E-06	-9.2750
2.0	7.30E-05	-9.5248	7.28E-06	-9.2937
2.5	6.70E-05	-9.6111	1.02E-05	-9.3261
3.0	6.57E-05	-9.6308	1.42E-05	-9.3717
4.0	6.00E-05	-9.7216	2.13E-05	-9.4595
5.0	5.32E-05	-9.8423	2.84E-05	-9.5550
6.0	4.90E-05	-9.9234	4.90E-05	-9.8970
7.0	4.22E-05	-10.0724	4.44E-05	-9.8109
8.0	3.42E-05	-10.2834	5.06E-05	-9.9306
9.0	2.94E-05	-10.4343	5.99E-05	-10.1434
10.0	2.27E-05	-10.6923	6.53E-05	-10.2909



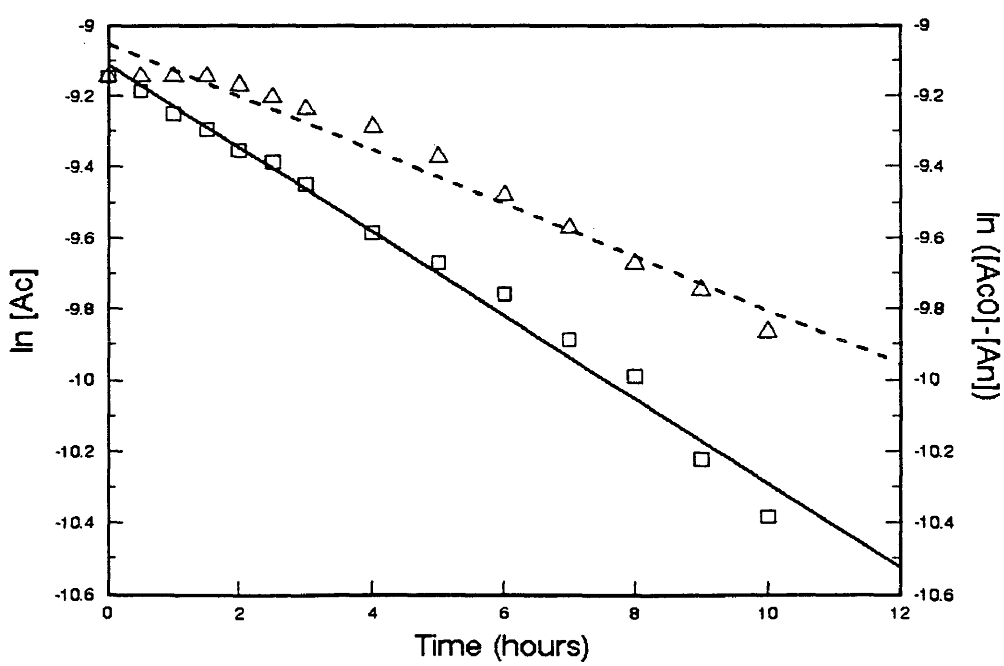
Bacterial Biolysis, Arthrobacter (DSMP), p-OCH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 2.59+/-0.08 x 10E-05 sec-1. r = 0.9937, b = -9.289+/-0.016, ssr = 0.0155.				
k obs. (appearance of product) = 3.01+/-0.63 x 10E-06 sec-1. r = 0.8106, b = -9.248+/-0.012, ssr = 0.00887.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.44E-05	-9.2680	0.00E+00	-9.2680
0.5	8.59E-05	-9.3622	0.00E+00	-9.2680
1.0	8.33E-05	-9.3928	0.00E+00	-9.2680
1.5	7.80E-05	-9.4590	0.00E+00	-9.2680
2.0	7.68E-05	-9.4746	0.00E+00	-9.2680
2.5	7.38E-05	-9.5144	0.00E+00	-9.2680
3.0	6.89E-05	-9.5823	0.00E+00	-9.2680
4.0	6.71E-05	-9.6090	0.00E+00	-9.2680
5.0	5.88E-05	-9.7410	1.49E-06	-9.2840
6.0	5.14E-05	-9.8750	4.74E-06	-9.3196
7.0	4.82E-05	-9.9407	3.14E-06	-9.3019
8.0	4.45E-05	-10.0201	5.64E-06	-9.3296
9.0	4.24E-05	-10.0688	3.58E-06	-9.3067
10.0	3.38E-05	-10.2962	1.39E-05	-9.4272



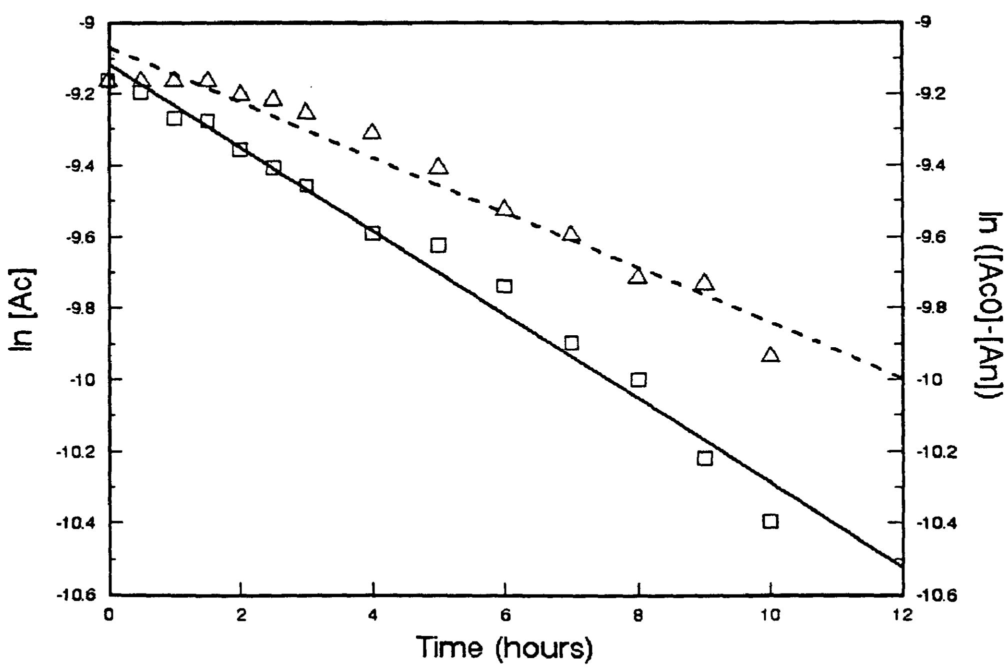
Bacterial Biolysis, Arthrobacter (DSMP), p-OCH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 2.59+/-0.09 x 10E-05 sec-1. r = 0.9927, b = -9.293+/-0.017, ssr = 0.0178.				
k obs. (appearance of product) = 3.31+/-0.68 x 10E-06 sec-1. r = 0.8157, b = -9.260+/-0.013, ssr = 0.0102.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	9.30E-05	-9.2828	0.00E+00	-9.2828
0.5	8.41E-05	-9.3831	0.00E+00	-9.2828
1.0	8.36E-05	-9.3895	0.00E+00	-9.2828
1.5	7.76E-05	-9.4635	0.00E+00	-9.2828
2.0	7.60E-05	-9.4845	0.00E+00	-9.2828
2.5	7.46E-05	-9.5032	0.00E+00	-9.2828
3.0	7.04E-05	-9.5609	0.00E+00	-9.2828
4.0	6.69E-05	-9.6122	0.00E+00	-9.2828
5.0	5.85E-05	-9.7464	1.44E-06	-9.2984
6.0	5.20E-05	-9.8646	4.46E-06	-9.3319
7.0	4.82E-05	-9.9391	3.33E-06	-9.3193
8.0	4.45E-05	-10.0208	6.59E-06	-9.3563
9.0	4.22E-05	-10.0734	4.07E-06	-9.3276
10.0	3.33E-05	-10.3101	1.47E-05	-9.4552



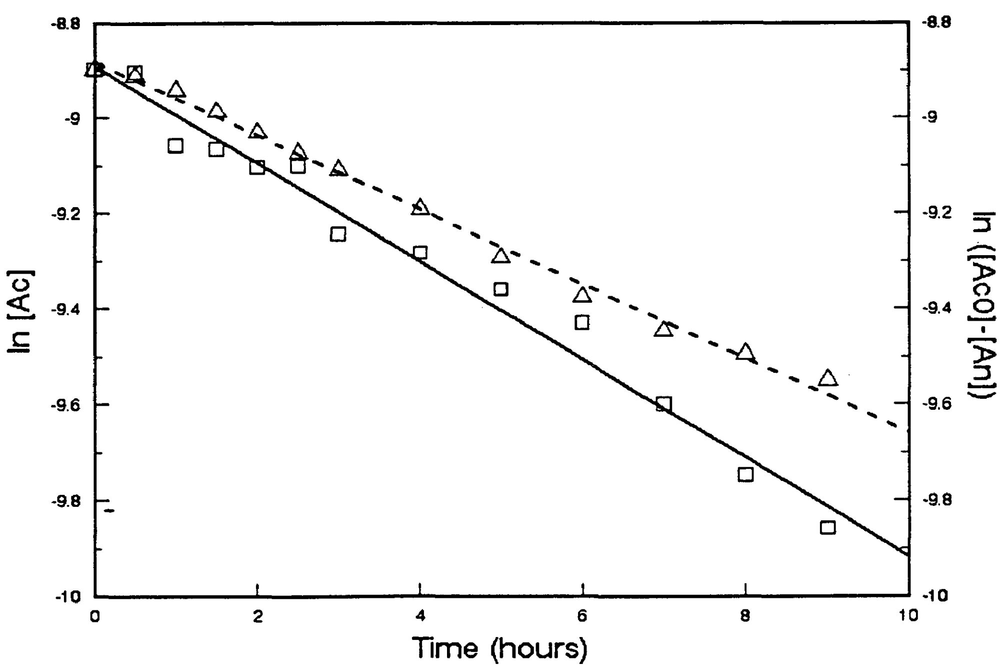
Bacterial Biolysis, Arthrobacter (DSMP), p-CH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 3.27+/-0.11 x 10E-05 sec-1. r = 0.9938, b = -9.112+/-0.020, ssr = 0.0245.				
k obs. (appearance of product) = 2.09+/-0.12 x 10E-05 sec-1. r = 0.9823, b = -9.052+/-0.022, ssr = 0.0288.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.07E-04	-9.1464	0.00E+00	-9.1464
0.5	1.02E-04	-9.1874	0.00E+00	-9.1464
1.0	9.59E-05	-9.2521	0.00E+00	-9.1464
1.5	9.17E-05	-9.2966	0.00E+00	-9.1464
2.0	8.67E-05	-9.3536	2.48E-06	-9.1700
2.5	8.37E-05	-9.3881	6.18E-06	-9.2062
3.0	7.87E-05	-9.4503	9.32E-06	-9.2379
4.0	6.86E-05	-9.5875	1.41E-05	-9.2886
5.0	6.30E-05	-9.6716	2.16E-05	-9.3727
6.0	5.77E-05	-9.7607	3.04E-05	-9.4817
7.0	5.08E-05	-9.8871	3.70E-05	-9.5732
8.0	4.58E-05	-9.9908	4.37E-05	-9.6744
9.0	3.63E-05	-10.2224	4.81E-05	-9.7471
10.0	3.10E-05	-10.3829	5.46E-05	-9.8652



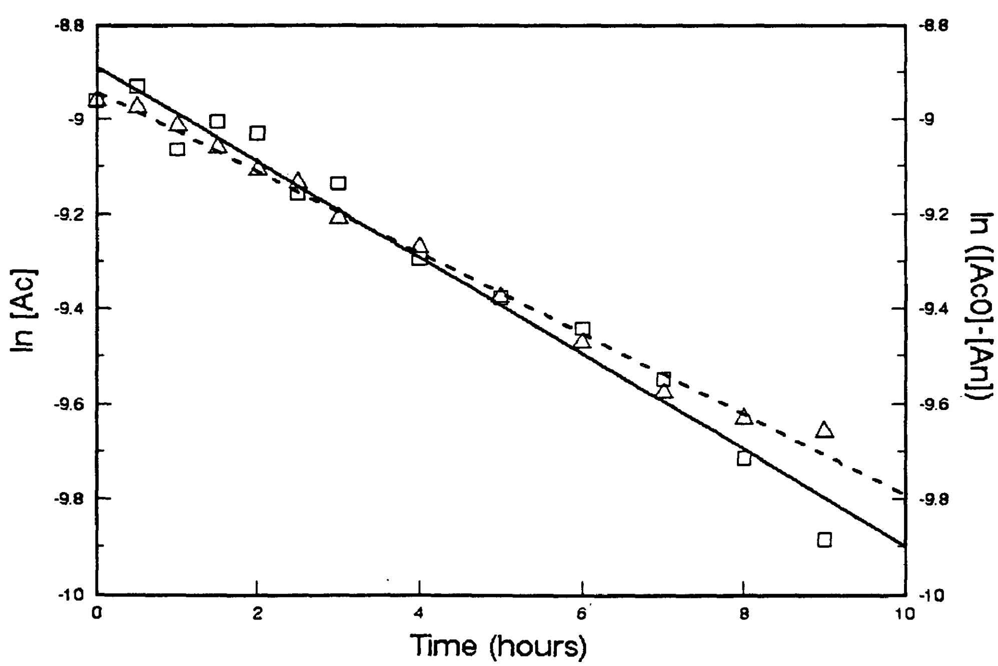
Bacterial Biolysis, Arthrobacter (DSMP), p-CH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 3.25+/-0.13 x 10E-05 sec-1. r = 0.9911, b = -9.116+/-0.024, ssr = 0.0350.				
k obs. (appearance of product) = 2.14+/-0.13 x 10E-05 sec-1. r = 0.9796, b = -9.069+/-0.024, ssr = 0.0354.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.05E-04	-9.1643	0.00E+00	-9.1643
0.5	1.02E-04	-9.1954	0.00E+00	-9.1643
1.0	9.44E-05	-9.2684	0.00E+00	-9.1643
1.5	9.36E-05	-9.2768	0.00E+00	-9.1643
2.0	8.63E-05	-9.3578	3.99E-06	-9.2031
2.5	8.22E-05	-9.4066	5.49E-06	-9.2181
3.0	7.81E-05	-9.4575	9.01E-06	-9.2542
4.0	6.84E-05	-9.5901	1.42E-05	-9.3100
5.0	6.61E-05	-9.6240	2.26E-05	-9.4075
6.0	5.90E-05	-9.7386	3.17E-05	-9.5249
7.0	5.03E-05	-9.8969	3.67E-05	-9.5952
8.0	4.54E-05	-10.0007	4.44E-05	-9.7163
9.0	3.64E-05	-10.2199	4.54E-05	-9.7331
10.0	3.06E-05	-10.3942	5.63E-05	-9.9356



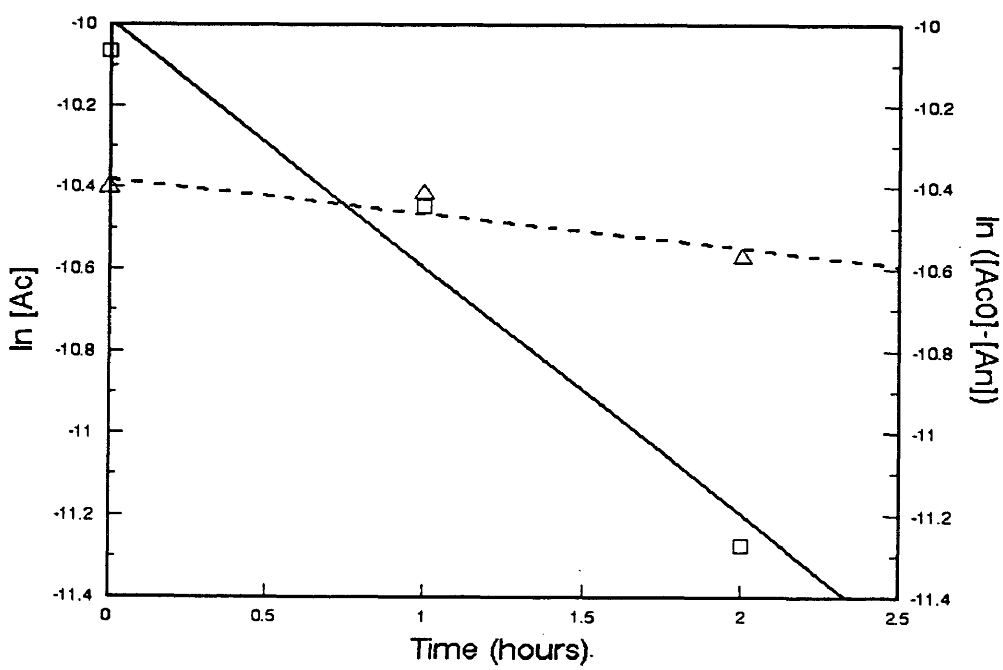
Bacterial Biolysis, Arthrobacter (DSMP), p-NO2-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 2.85+/-0.12 x 10E-5 sec-1. r = 0.9904, b = -8.890+/-0.021, ssr = 0.0216.				
k obs. (appearance of product) = 2.16+/-0.05 x 10E-05 sec-1. r = 0.9972, b = -8.880+/-0.008, ssr = 0.00371.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.37E-04	-8.8984	0.00E+00	-8.8984
0.5	1.36E-04	-8.9031	1.93E-06	-8.9126
1.0	1.17E-04	-9.0570	5.66E-06	-8.9408
1.5	1.16E-04	-9.0652	1.16E-05	-8.9870
2.0	1.11E-04	-9.1041	1.69E-05	-9.0304
2.5	1.12E-04	-9.1002	2.19E-05	-9.0727
3.0	9.68E-05	-9.2431	2.59E-05	-9.1090
4.0	9.30E-05	-9.2825	3.46E-05	-9.1908
5.0	8.61E-05	-9.3596	4.45E-05	-9.2928
6.0	8.02E-05	-9.4304	5.19E-05	-9.3765
7.0	6.77E-05	-9.5999	5.76E-05	-9.4466
8.0	5.85E-05	-9.7469	6.14E-05	-9.4952
9.0	5.23E-05	-9.8581	6.54E-05	-9.5498



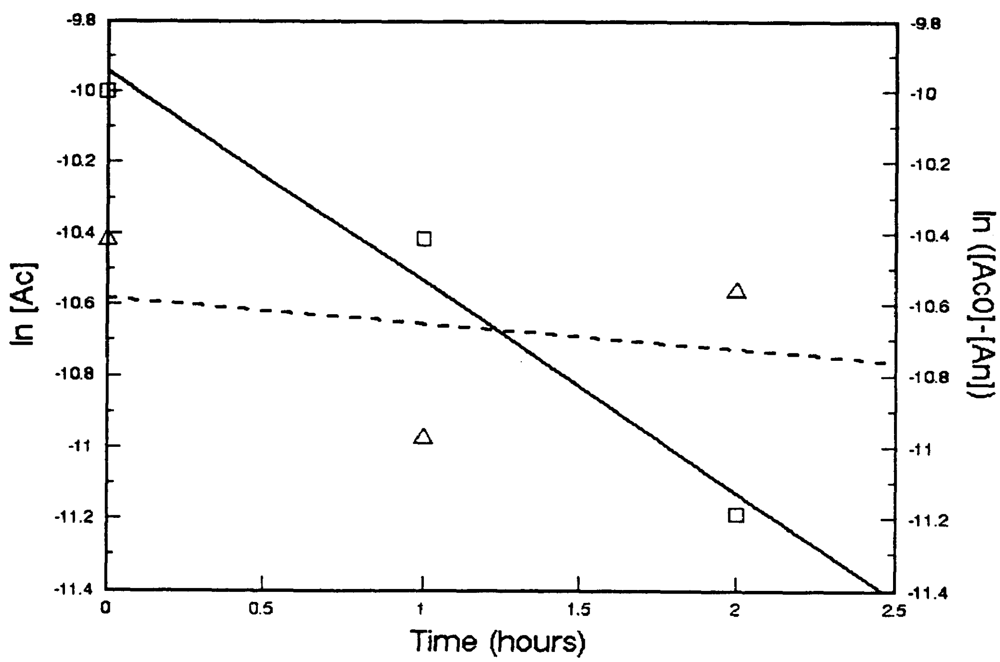
Bacterial Biolysis, Arthrobacter (DSMP), p-NO2-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 2.80+/-0.15 x 10E-05 sec-1. r = 0.9854, b = -8.889+/-0.025, ssr = 0.0320.				
k obs. (appearance of product) = 2.37+/-0.06 x 10E-05 sec-1. r = 0.9961, b = -8.941+/-0.011, ssr = 0.00590.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.28E-04	-8.9608	0.00E+00	-8.9608
0.5	1.32E-04	-8.9308	1.71E-06	-8.9742
1.0	1.16E-04	-9.0645	6.74E-06	-9.0148
1.5	1.23E-04	-9.0058	1.21E-05	-9.0601
2.0	1.20E-04	-9.0308	1.74E-05	-9.1066
2.5	1.05E-04	-9.1585	2.05E-05	-9.1344
3.0	1.08E-04	-9.1364	2.82E-05	-9.2087
4.0	9.18E-05	-9.2959	3.43E-05	-9.2713
5.0	8.46E-05	-9.3782	4.36E-05	-9.3759
6.0	7.93E-05	-9.4429	5.14E-05	-9.4725
7.0	7.13E-05	-9.5490	5.91E-05	-9.5776
8.0	6.05E-05	-9.7135	6.27E-05	-9.6310
9.0	5.09E-05	-9.8847	6.45E-05	-9.6591



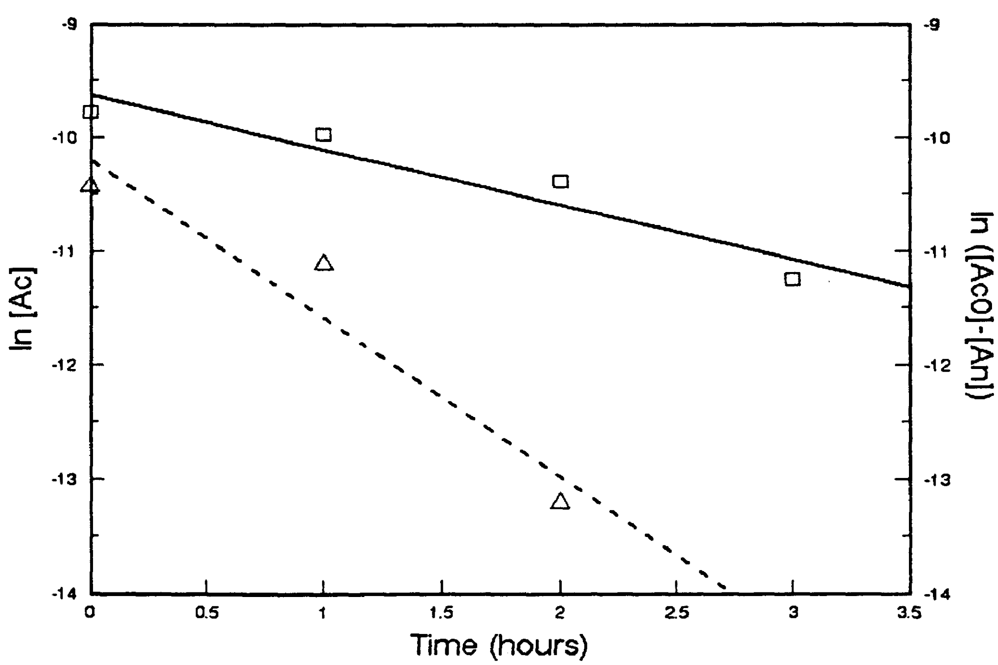
Bacterial Biolysis, Pseudomonas (CCS), acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.68+/-0.36 x 10E-04 sec-1. r = 0.9780, b = -9.992+/-0.166, ssr = 0.0332.				
k obs. (appearance of product) = 2.36+/-1.14 x 10E-05 sec-1. r = 0.8999, b = -10.378+/-0.053, ssr = 0.00338.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	4.25E-05	-10.0663	1.21E-05	-10.4022
1.0	2.90E-05	-10.4469	1.25E-05	-10.4158
2.0	1.27E-05	-11.2740	1.69E-05	-10.5718



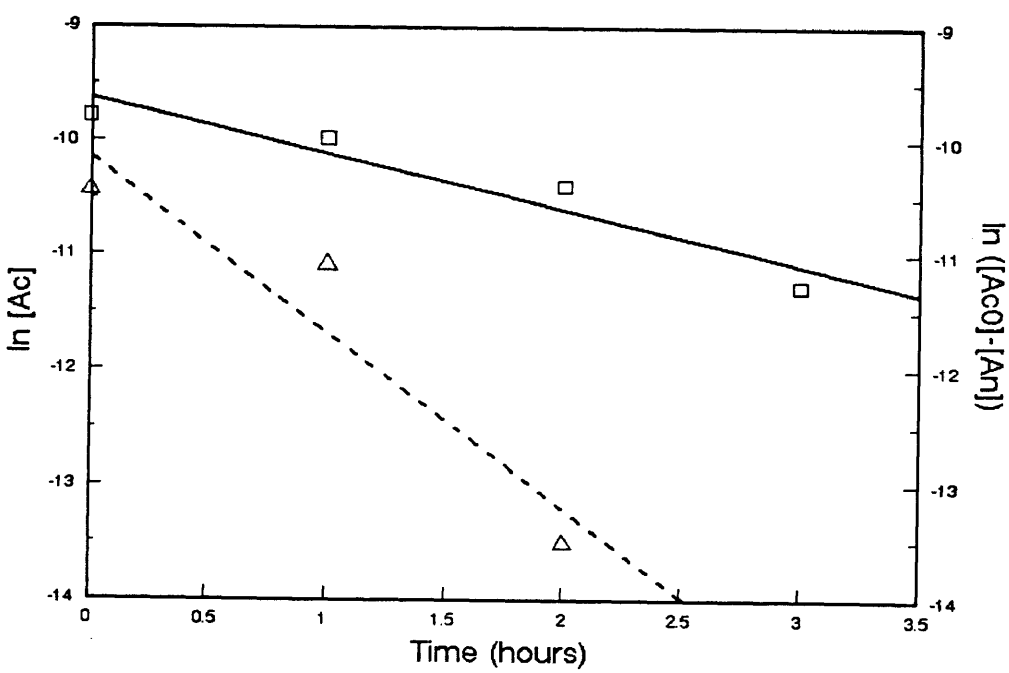
Bacterial Biolysis, Pseudomonas (CCS), acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.65+/-0.28 x 10E-04 sec-1. r = 0.9856, b = -9.941+/-0.132, ssr = 0.0208.				
k obs. (appearance of product) = 2.01+/-7.76 x 10E-05 sec-1. r = 0.2507, b = -10.581+/-0.361, ssr = 0.156.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	4.54E-05	-9.9996	1.56E-05	-10.4194
1.0	2.99E-05	-10.4169	2.83E-05	-10.9756
2.0	1.38E-05	-11.1873	1.96E-05	-10.5641



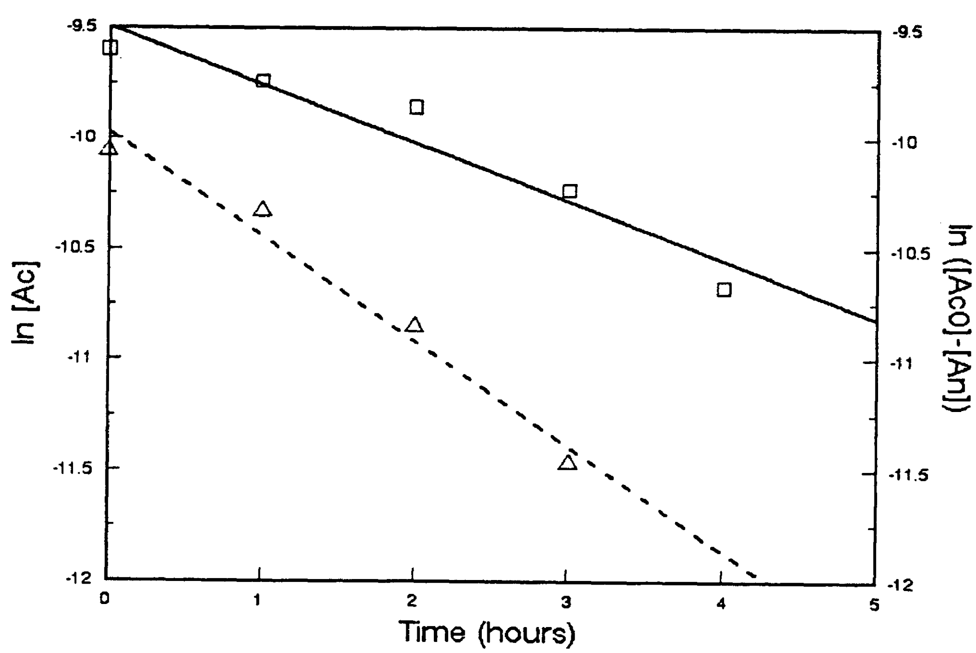
Bacterial Biolysis, Pseudomonas (CCS), p-Br-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.34+/-0.30 x 10E-04 sec-1. r = 0.9544, b = -9.627+/-0.200, ssr = 0.114.				
k obs. (appearance of product) = 3.85+/-1.13 x 10E-04 sec-1. r = 0.9596, b = -10.200+/-0.526, ssr = 0.331.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	5.65E-05	-9.7817	2.71E-05	-10.4353
1.0	4.64E-05	-9.9775	4.16E-05	-11.1179
2.0	3.07E-05	-10.3902	5.46E-05	-13.2106
3.0	1.30E-05	-11.2532	6.77E-05	ERR



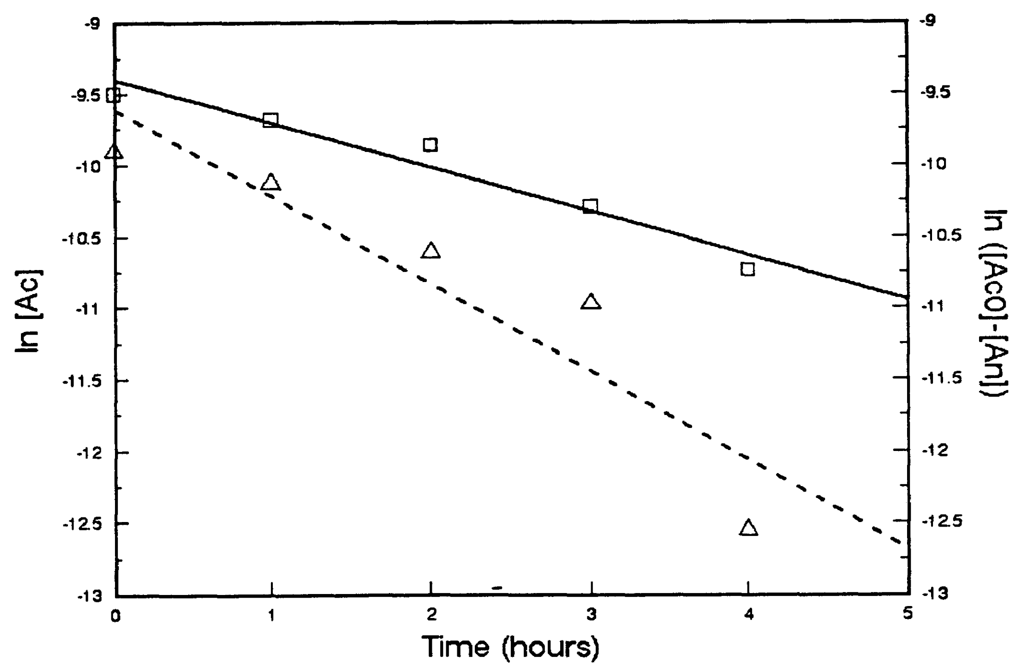
Bacterial Biolysis, Pseudomonas (CCS), p-Br-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.36+/-0.30 x 10E-04 sec-1. r = 0.9535, b = -9.622+/-0.205, ssr = 0.120.				
k obs. (appearance of product) = 4.26+/-1.43 x 10E-04 sec-1. r = 0.9481, b = -10.145+/-0.664, ssr = 0.529.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	5.65E-05	-9.7813	2.73E-05	-10.4415
1.0	4.65E-05	-9.9755	4.11E-05	-11.0838
2.0	3.06E-05	-10.3952	5.51E-05	-13.5081
3.0	1.27E-05	-11.2738	6.84E-05	ERR



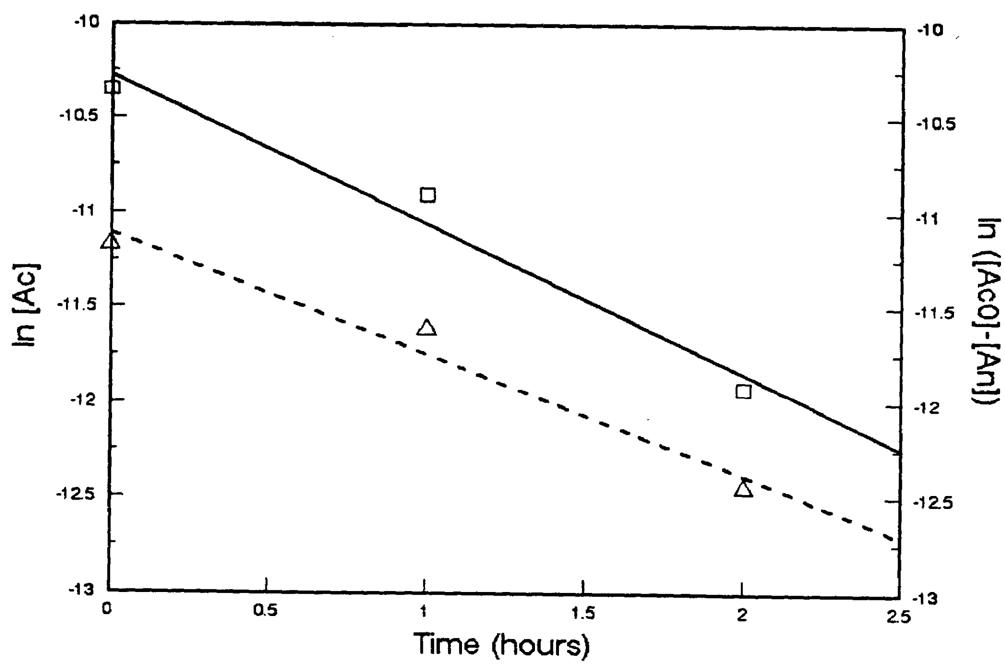
Bacterial Biolysis, Pseudomonas, (CCS), p-CN-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 7.32+/-1.20 x 10E-05 sec-1. r = 0.9622, b = -9.494+/-0.106, ssr = 0.0558.				
k obs. (appearance of product) = 1.32+/-0.15 x 10E-04 sec-1. r = 0.9865, b = -9.969+/-0.104, ssr = 0.0309.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	6.78E-05	-9.5982	2.52E-05	-10.0627
1.0	5.87E-05	-9.7438	3.54E-05	-10.3353
2.0	5.24E-05	-9.8575	4.85E-05	-10.8514
3.0	3.60E-05	-10.2332	5.74E-05	-11.4699
4.0	2.32E-05	-10.6720	6.79E-05	ERR



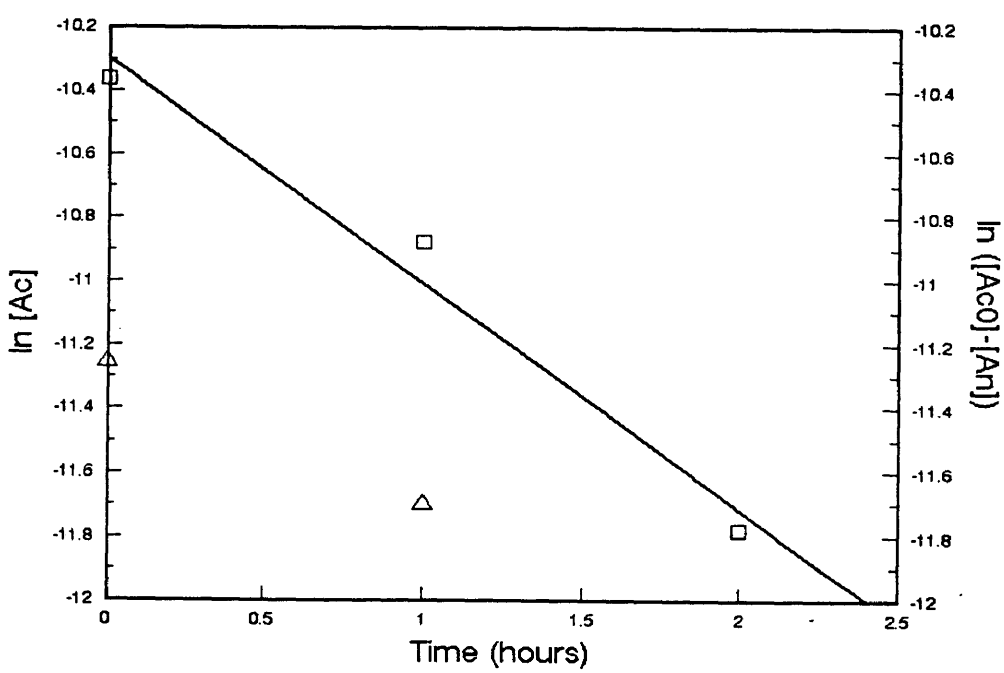
Bacterial Biolysis, Pseudomonas, (CCS), p-CN-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 8.59+/-1.09 x 10E-05 sec-1. r = 0.9765, b = -9.396+/-0.096, ssr = 0.0465.				
k obs. (appearance of product) = 1.70+/-0.40 x 10E-04 sec-1. r = 0.9278, b = -9.607+/-0.349, ssr = 0.609.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	7.50E-05	-9.4980	2.51E-05	-9.9052
1.0	6.24E-05	-9.6821	3.50E-05	-10.1276
2.0	5.22E-05	-9.8600	5.04E-05	-10.6133
3.0	3.38E-05	-10.2961	5.79E-05	-10.9749
4.0	2.17E-05	-10.7374	7.15E-05	-12.5501



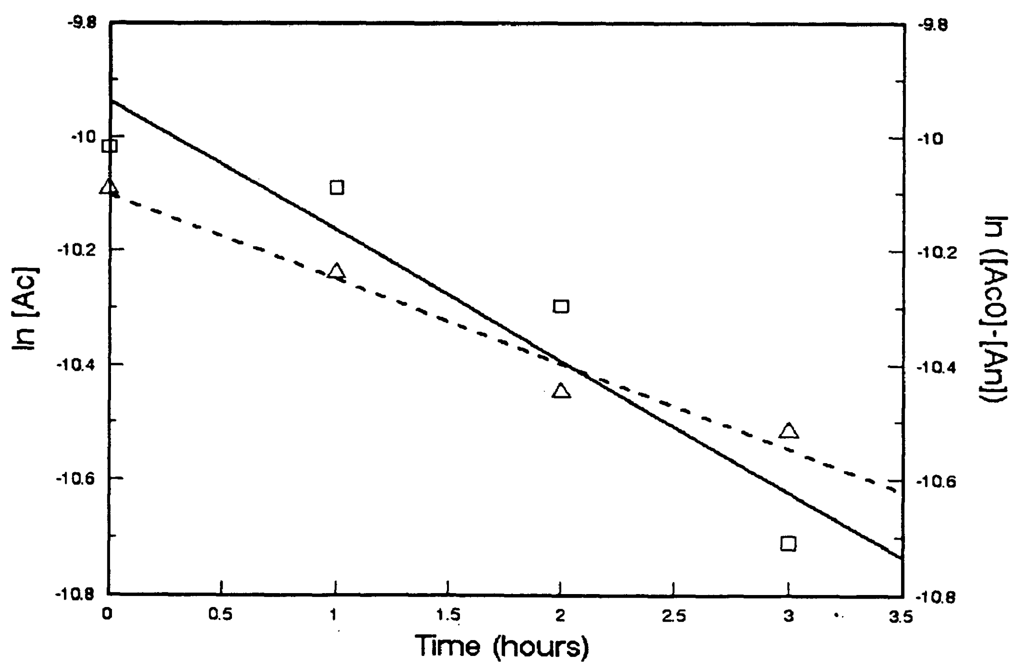
Bacterial Biolysis, Pseudomonas (CCS), p-F-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 2.19+/-0.38 x 10E-04 sec-1. r = 0.9855, b = -10.273+/-0.175, ssr = 0.0369.				
k obs. (appearance of product) = 1.77+/-0.31 x 10E-04 sec-1. r = 0.9846, b = -11.110+/-0.146, ssr = 0.0256.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	3.20E-05	-10.3509	1.79E-05	-11.1748
1.0	1.84E-05	-10.9045	2.29E-05	-11.6165
2.0	6.60E-06	-11.9285	2.80E-05	-12.4499



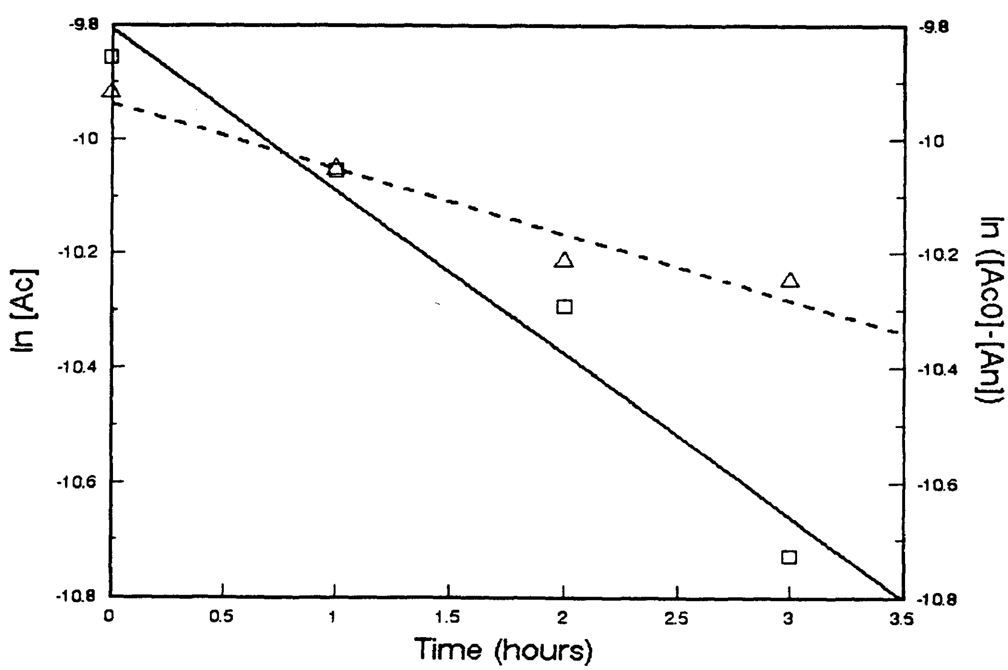
Bacterial Biolysis, Pseudomonas (CCS), p-F-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.97+/-0.31 x 10E-04 sec-1. r = 0.9877, b = -10.299+/-0.145, ssr = 0.0251.				
k obs. (appearance of product) = 1.24 x 10E-04 sec-1. r 0.9999, b = -11.255.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	3.15E-05	-10.3641	1.86E-05	-11.2547
1.0	1.89E-05	-10.8786	2.33E-05	-11.7008
2.0	7.65E-06	-11.7811	3.16E-05	ERR



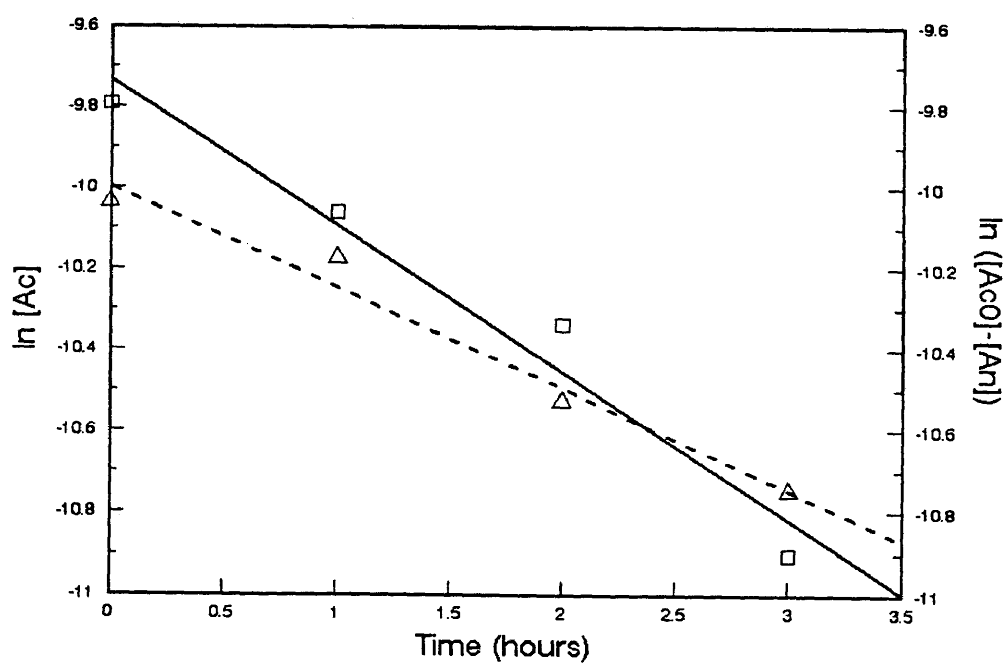
Bacterial Biolysis, Pseudomonas (CCS), p-OCH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 6.34+/-1.51 x 10E-05 sec-1. r = 0.9480, b = -9.936+/-0.101, ssr = 0.0294.				
k obs. (appearance of product) = 4.11+/-0.53 x 10E-05 sec-1. r = 0.9837, b = -10.102+/-0.036, ssr = 0.00365.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	4.46E-05	-10.0181	3.17E-06	-10.0919
1.0	4.15E-05	-10.0895	8.84E-06	-10.2389
2.0	3.37E-05	-10.2969	1.56E-05	-10.4478
3.0	2.23E-05	-10.7097	1.75E-05	-10.5153



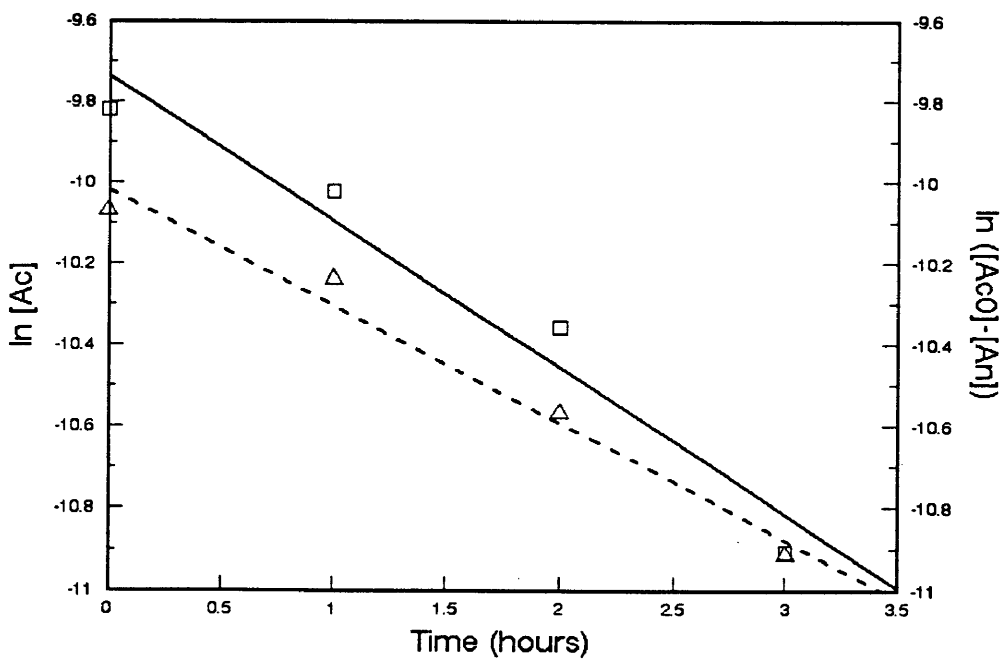
Bacterial Biolysis, Pseudomonas (CCS), p-OCH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 7.92+/-1.09 x 10E-05 sec-1. r = 0.9816, b = -9.806+/-0.073, ssr = 0.0153.				
k obs. (appearance of product) = 3.19+/-0.53 x 10E-05 sec-1. r = 0.9731, b = -9.936+/-0.036, ssr = 0.00367.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	5.24E-05	-9.8570	3.16E-06	-9.9192
1.0	4.29E-05	-10.0560	9.30E-06	-10.0524
2.0	3.39E-05	-10.2924	1.57E-05	-10.2142
3.0	2.19E-05	-10.7276	1.70E-05	-10.2484



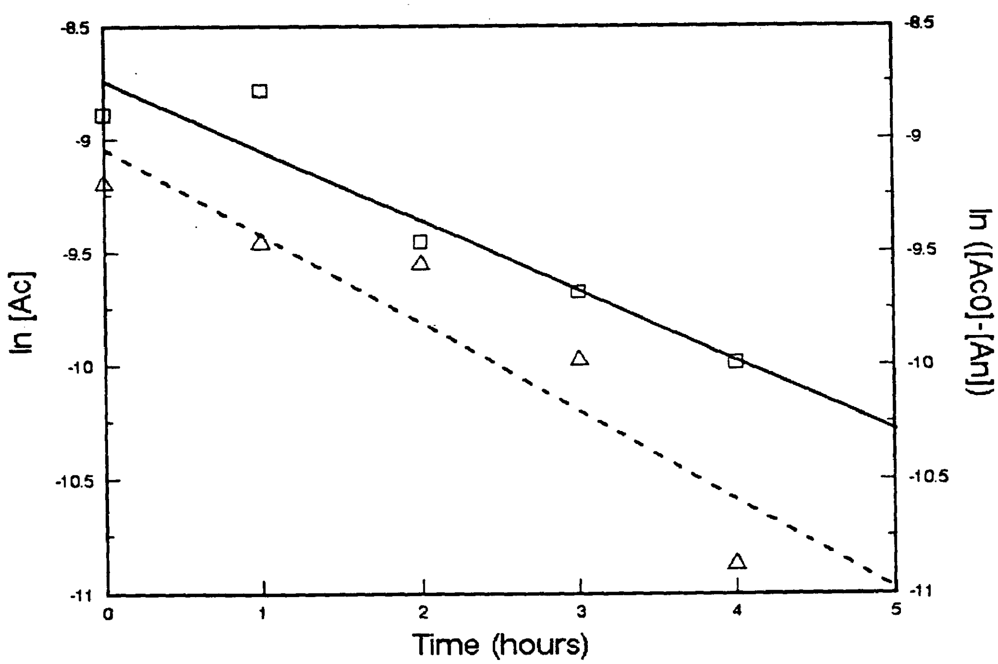
Bacterial Biolysis, Pseudomonas (CCS), p-CH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.00+/-0.14 x 10E-04 sec-1. r = 0.9805, b = -9.732+/-0.096, ssr = 0.0263.				
k obs. (appearance of product) = 6.91+/-0.78 x 10E-05 sec-1. r = 0.9875, b = -9.998+/-0.052, ssr = 0.00788.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	5.59E-05	-9.7925	1.21E-05	-10.0366
1.0	4.27E-05	-10.0621	1.77E-05	-10.1737
2.0	3.24E-05	-10.3381	2.91E-05	-10.5278
3.0	1.83E-05	-10.9060	3.44E-05	-10.7473



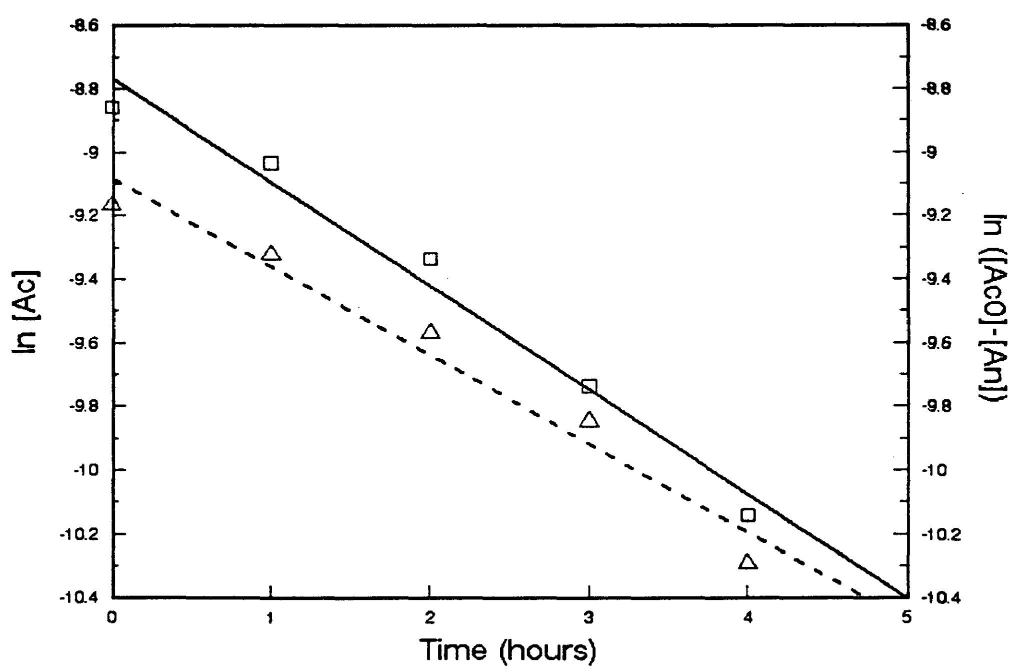
Bacterial Biolysis, Pseudomonas (CCS), p-CH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.00+/-0.15 x 10E-04 sec-1. r = 0.9771, b = -9.736+/-0.104, ssr = 0.0306.				
k obs. (appearance of product) = 7.97+/-0.83 x 10E-05 sec-1. r = 0.9892, b = -10.018+/-0.056, ssr = 0.00905.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	5.44E-05	-9.8189	1.21E-05	-10.0700
1.0	4.44E-05	-10.0217	1.86E-05	-10.2384
2.0	3.18E-05	-10.3565	2.87E-05	-10.5685
3.0	1.83E-05	-10.9072	3.62E-05	-10.9159



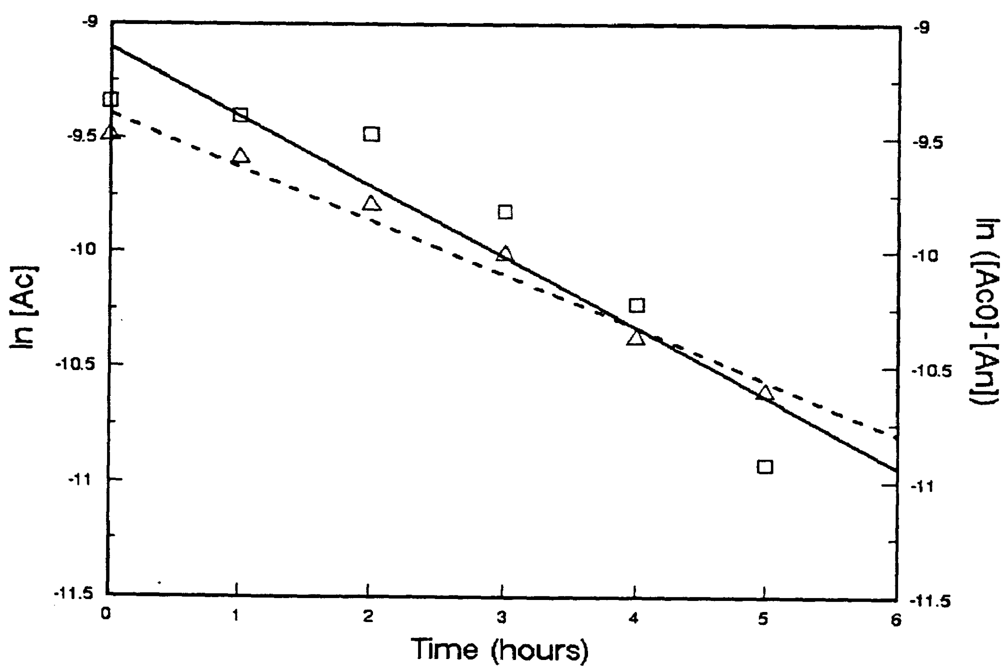
Bacterial Biolysis, Pseudomonas (CCS), p-NO2-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 8.56+/-1.62 x 10E-05 sec-1. r = 0.9501, b = -8.745+/-0.143, ssr = 0.102.				
k obs. (appearance of product) = 1.08+/-0.24 x 10E-04 sec-1. r = 0.9323, b = -9.040+/-0.213, ssr = 0.226.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.37E-04	-8.8945	3.61E-05	-9.1997
1.0	1.53E-04	-8.7869	5.93E-05	-9.4607
2.0	7.82E-05	-9.4562	6.63E-05	-9.5556
3.0	6.27E-05	-9.6779	9.08E-05	-9.9803
4.0	4.59E-05	-9.9896	1.18E-04	-10.8779



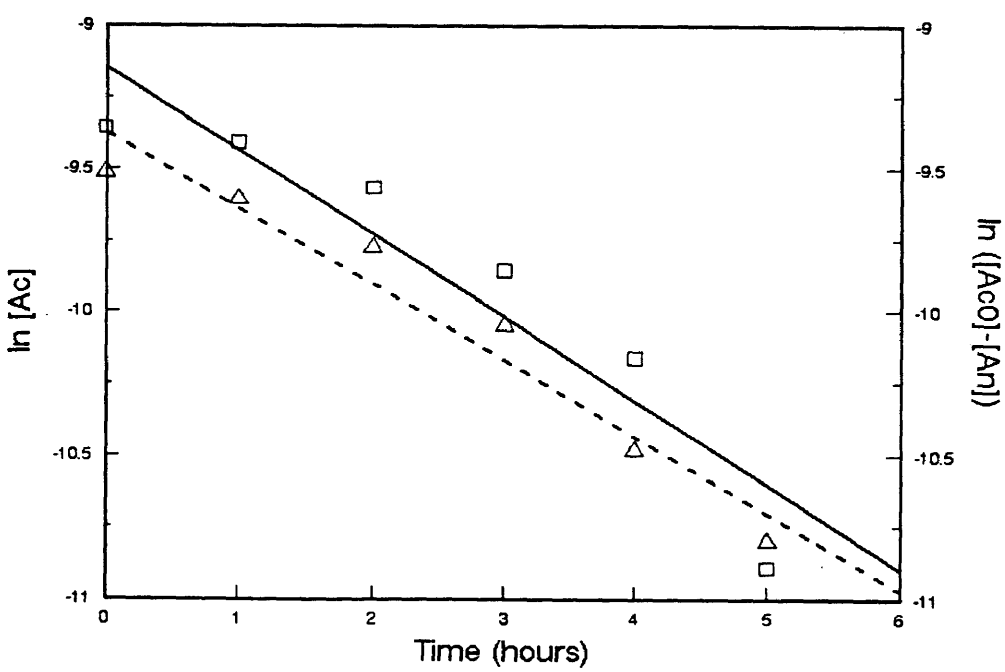
Bacterial Biolysis, Pseudomonas (CCS), p-NO2-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 9.08+/-0.78 x 10E-05 sec-1. r = 0.9890, b = -8.769+/-0.069, ssr = 0.0239.				
k obs. (appearance of product) = 7.72+/-0.85 x 10E-05 sec-1. r = 0.9825, b = -9.085+/-0.075, ssr = 0.0279.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	1.42E-04	-8.8599	3.75E-05	-9.1668
1.0	1.19E-04	-9.0345	5.27E-05	-9.3237
2.0	8.81E-05	-9.3367	7.22E-05	-9.5700
3.0	5.89E-05	-9.7388	8.91E-05	-9.8476
4.0	3.94E-05	-10.1423	1.08E-04	-10.2944



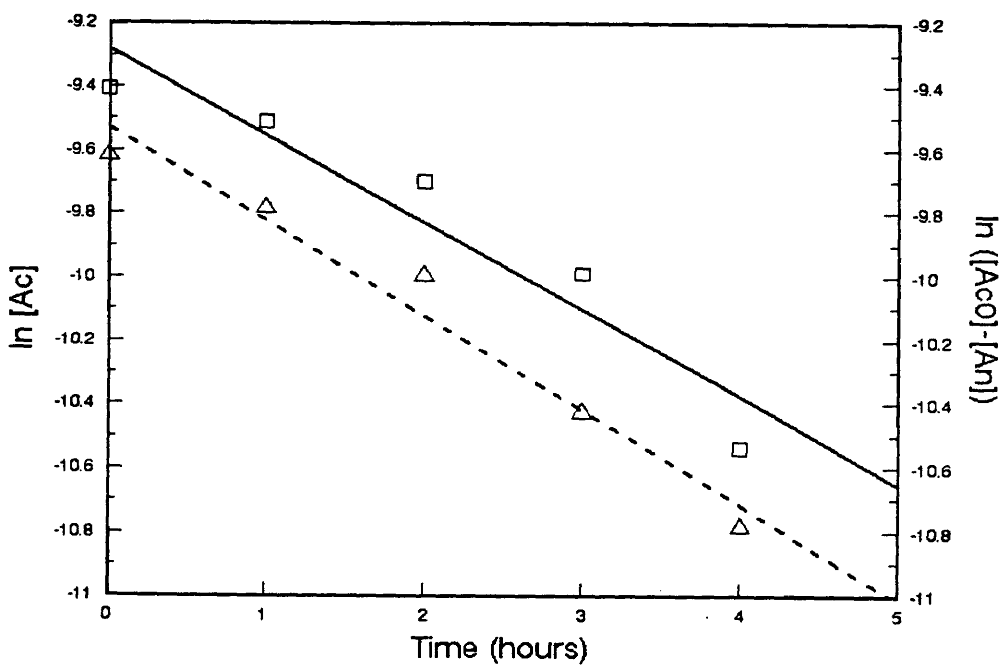
Bacterial Biolysis, Bacillus (B.EPA), acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 8.52+/-1.64 x 10E-05 sec-1. r = 0.9330, b = -9.100+/-0.179, ssr = 0.245.				
k obs. (appearance of product) = 6.48+/-0.55 x 10E-05 sec-1. r = 0.9858, b = -9.395+/-0.060, ssr = 0.0278.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.79E-05	-9.3392	1.25E-05	-9.4930
1.0	8.25E-05	-9.4029	1.93E-05	-9.5876
2.0	7.61E-05	-9.4830	3.21E-05	-9.7936
3.0	5.42E-05	-9.8226	4.30E-05	-10.0098
4.0	3.63E-05	-10.2239	5.67E-05	-10.3762
5.0	1.80E-05	-10.9250	6.33E-05	-10.6104



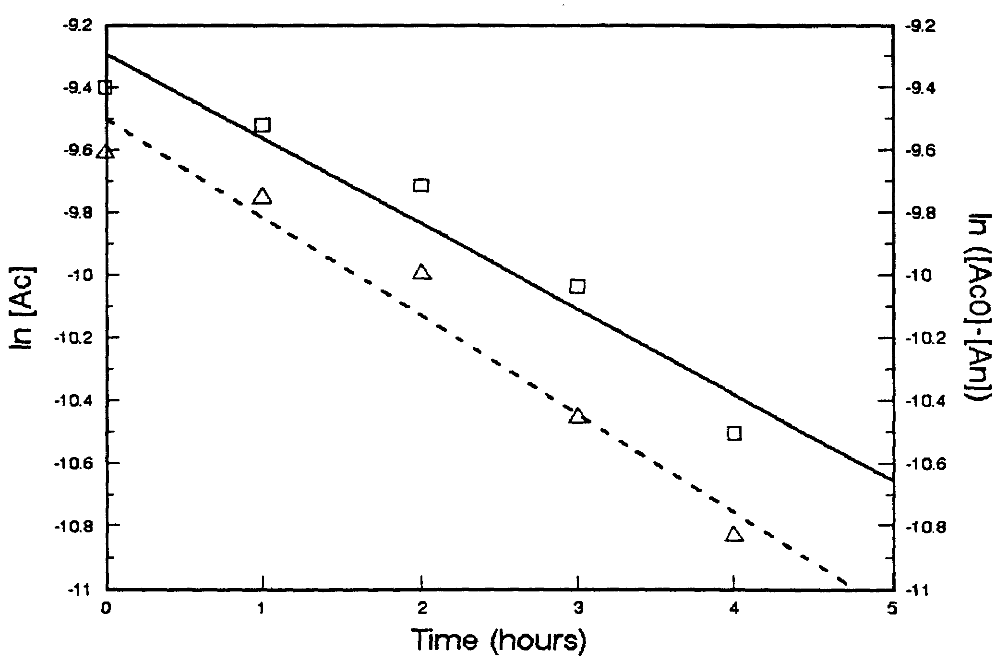
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
Bacterial Biolysis, Bacillus (B.EPA), acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 8.11+/-1.49 x 10E-05 sec-1. r = 0.9383, b = -9.144+/-0.163, ssr = 0.203.				
k obs. (appearance of product) = 7.41+/-0.84 x 10E-05 sec-1. r = 0.9751, b = -9.372+/-0.092, ssr = 0.0644.				
0.0	8.64E-05	-9.3568	1.26E-05	-9.5144
1.0	8.18E-05	-9.4111	1.91E-05	-9.6071
2.0	7.00E-05	-9.5670	2.96E-05	-9.7764
3.0	5.24E-05	-9.8575	4.31E-05	-10.0478
4.0	3.85E-05	-10.1642	5.84E-05	-10.4838
5.0	1.86E-05	-10.8915	6.60E-05	-10.8002



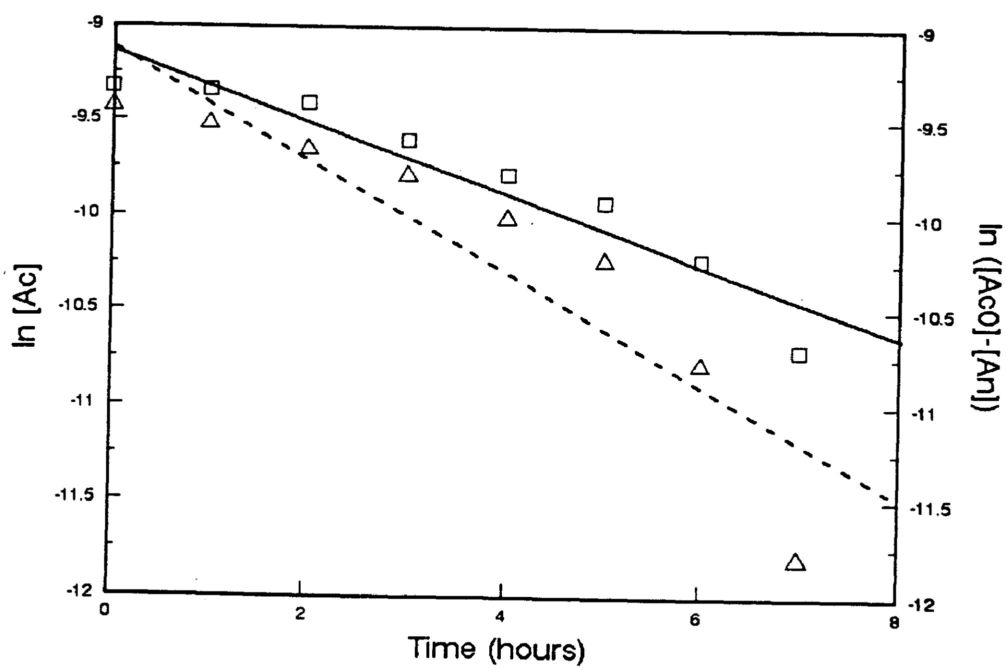
Bacterial Biolysis, Bacillus (B.EPA), p-Br-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 7.61+/-1.38 x 10E-05 sec-1. r = 0.9541, b = -9.282+/-0.122, ssr = 0.0739.				
k obs. (appearance of product) = 8.27+/-0.89 x 10E-05 sec-1. r = 0.9831, b = -9.527+/-0.078, ssr = 0.0307.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.20E-05	-9.4083	1.55E-05	-9.6184
1.0	7.39E-05	-9.5123	2.57E-05	-9.7839
2.0	6.13E-05	-9.6998	3.64E-05	-9.9957
3.0	4.59E-05	-9.9900	5.24E-05	-10.4273
4.0	2.65E-05	-10.5394	6.13E-05	-10.7857



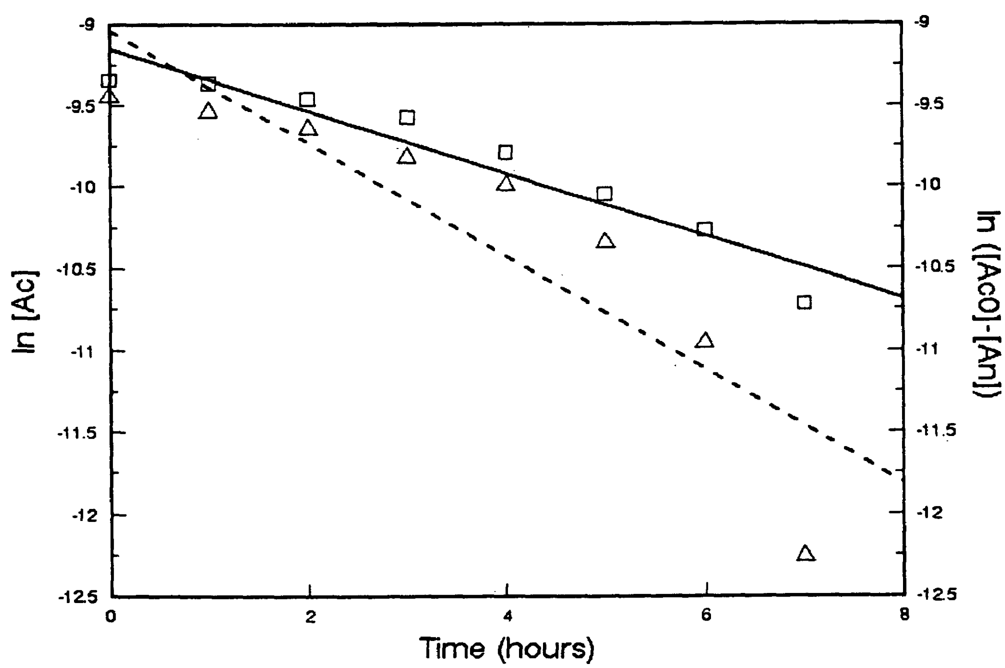
Bacterial Biolysis, Bacillus (B.EPA), p-Br-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 7.57+/-1.12 x 10E-05 sec-1. r = 0.9688, b = -9.292+/-0.099, ssr = 0.0486.				
k obs. (appearance of product) = 8.73+/-1.00 x 10E-05 sec-1. r = 0.9809, b = -9.503+/-0.088, ssr = 0.0386.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.26E-05	-9.4017	1.57E-05	-9.6122
1.0	7.31E-05	-9.5237	2.46E-05	-9.7549
2.0	6.03E-05	-9.7165	3.71E-05	-9.9981
3.0	4.36E-05	-10.0401	5.39E-05	-10.4581
4.0	2.74E-05	-10.5067	6.28E-05	-10.8314



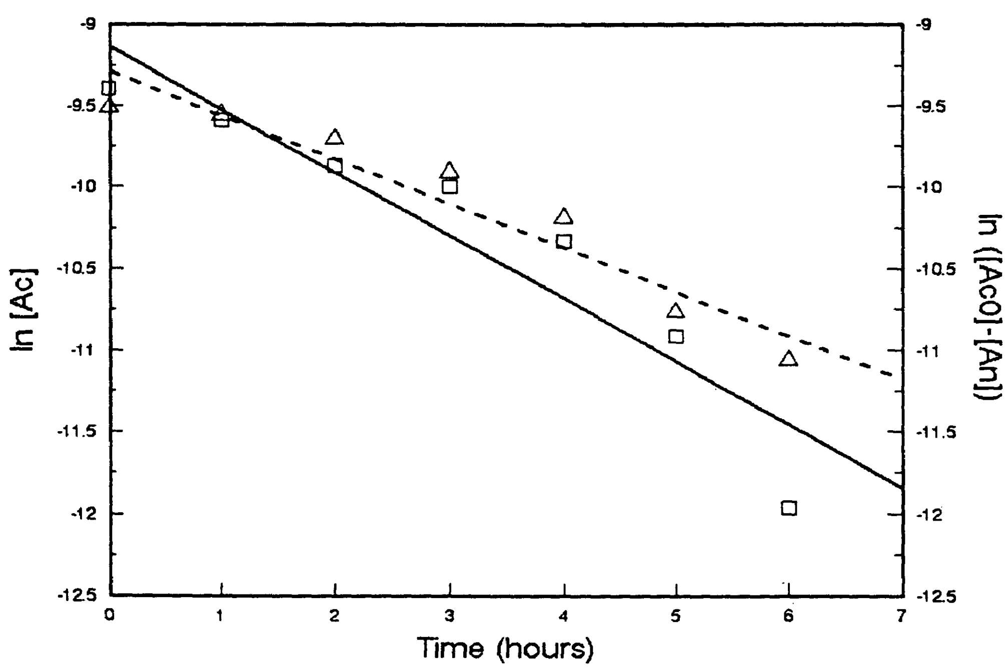
Bacterial Biolysis, Bacillus (B.EPA), p-CN-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 5.24+/-0.69 x 10E-05 sec-1. r = 0.9517, b = -9.132+/-0.104, ssr = 0.155.				
k obs. (appearance of product) = 8.23+/-1.52 x 10E-05 sec-1. r = 0.9108, b = -9.117+/-0.229, ssr = 0.758.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.90E-05	-9.3269	8.66E-06	-9.4292
1.0	8.76E-05	-9.3427	1.58E-05	-9.5218
2.0	8.19E-05	-9.4105	2.48E-05	-9.6535
3.0	6.75E-05	-9.6030	3.29E-05	-9.7878
4.0	5.65E-05	-9.7813	4.43E-05	-10.0147
5.0	4.88E-05	-9.9286	5.32E-05	-10.2374
6.0	3.60E-05	-10.2309	6.83E-05	-10.7836
7.0	2.24E-05	-10.7065	8.15E-05	-11.8012



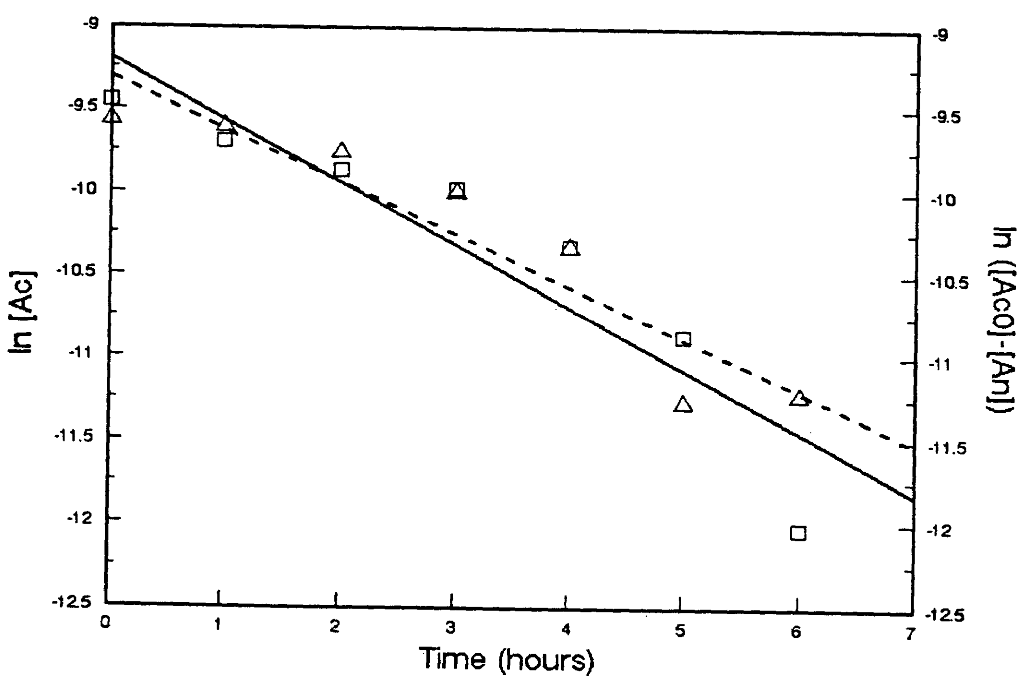
Bacterial Biolysis, Bacillus (B.EPA), p-CN-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 5.32+/-0.66 x 10E-05 sec-1. r = 0.9574, b = -9.149+/-0.099, ssr = 0.140.				
k obs. (appearance of product) = 9.61+/-2.00 x 10-05 sec-1. r = 0.8913, b = -9.041+/-0.301, ssr = 1.30.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.74E-05	-9.3455	8.69E-06	-9.4503
1.0	8.58E-05	-9.3633	1.55E-05	-9.5403
2.0	7.79E-05	-9.4603	2.25E-05	-9.6428
3.0	6.94E-05	-9.5751	3.30E-05	-9.8195
4.0	5.62E-05	-9.7874	4.16E-05	-9.9918
5.0	4.34E-05	-10.0446	5.52E-05	-10.3443
6.0	3.48E-05	-10.2665	7.00E-05	-10.9595
7.0	2.21E-05	-10.7195	8.26E-05	-12.2630



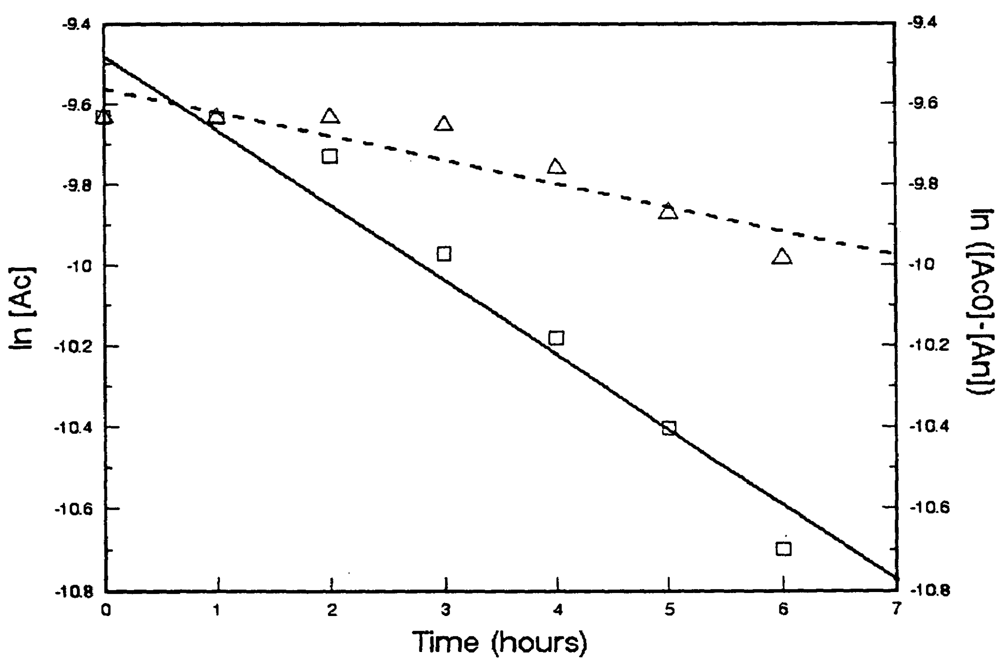
Bacterial Biolysis, Bacillus (B. EPA), p-F-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 1.07+/-0.18 x 10E-04 sec-1. r = 0.9383, b = -9.138+/-0.230, ssr = 0.568.				
k obs. (appearance of product) = 7.51+/-0.98 x 10E-05 sec-1. r = 0.9600, b = -9.288+/-0.127, ssr = 0.174.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.28E-05	-9.3987	8.75E-06	-9.5103
1.0	6.83E-05	-9.5910	1.20E-05	-9.5549
2.0	5.17E-05	-9.8702	2.17E-05	-9.7023
3.0	4.54E-05	-9.9998	3.31E-05	-9.9090
4.0	3.25E-05	-10.3329	4.52E-05	-10.1889
5.0	1.82E-05	-10.9167	6.18E-05	-10.7673
6.0	6.36E-06	-11.9651	6.72E-05	-11.0639



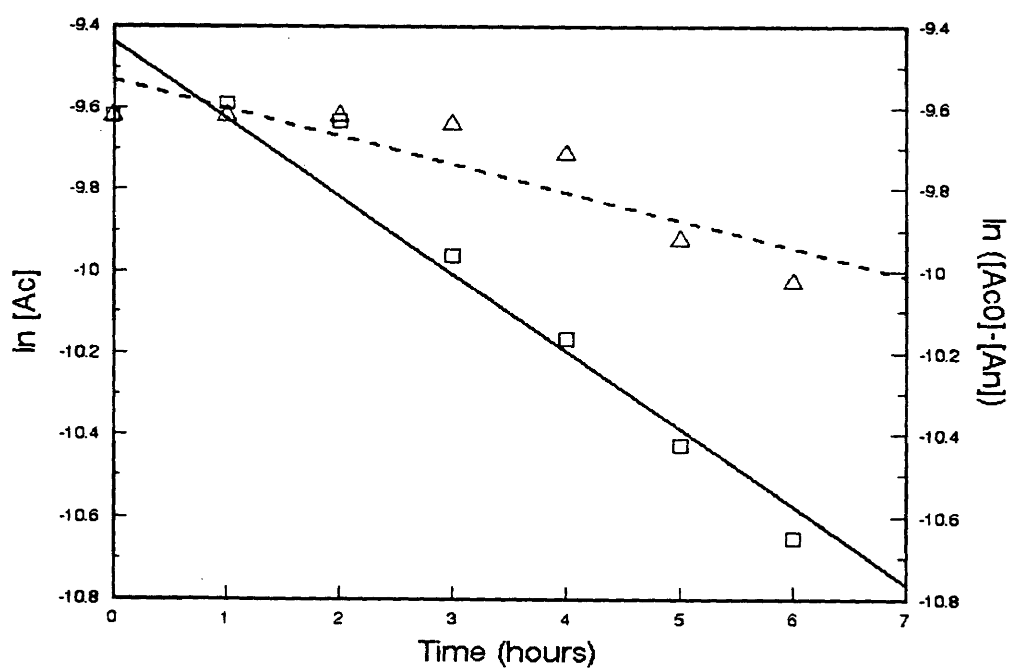
Bacterial Biolysis, Bacillus (B. EPA), p-F-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 1.05+/-0.20 x 10E-04 sec-1. r = 0.9199, b = -9.189+/-0.259, ssr = 0.723.				
k obs. (appearance of product) = 8.82+/-1.43 x 10E-05 sec-1. r = 0.9401, b = -9.301+/-0.186, ssr = 0.371.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	7.85E-05	-9.4521	8.79E-06	-9.5708
1.0	6.13E-05	-9.6995	1.15E-05	-9.6099
2.0	5.18E-05	-9.8686	2.10E-05	-9.7636
3.0	4.63E-05	-9.9808	3.33E-05	-10.0029
4.0	3.27E-05	-10.3295	4.60E-05	-10.3338
5.0	1.89E-05	-10.8737	6.58E-05	-11.2743
6.0	5.94E-06	-12.0339	6.53E-05	-11.2299



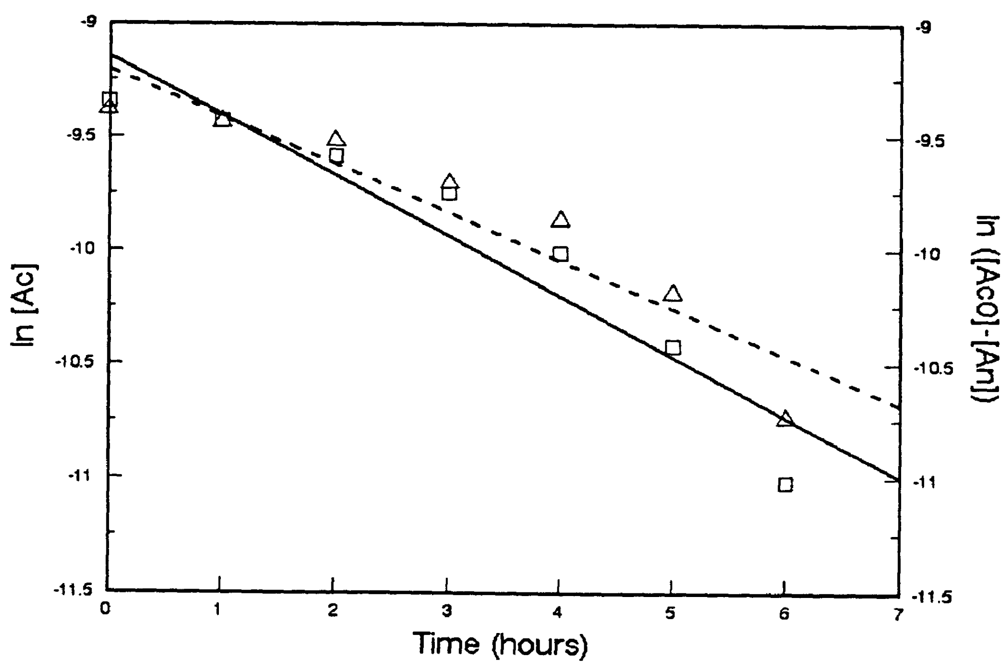
Bacterial Biolysis, Bacillus (B.EPA), p-OCH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 5.14+/-0.60 x 10E-05 sec-1. r = 0.9717, b = -9.481+/-0.073, ssr = 0.0569.				
k obs. (appearance of product) = 1.63+/-0.34 x 10E-05 sec-1. r = 0.9067, b = -9.562+/-0.044, ssr = 0.0211.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	6.55E-05	-9.6341	0.00E+00	-9.6341
1.0	6.54E-05	-9.6346	0.00E+00	-9.6341
2.0	5.95E-05	-9.7295	0.00E+00	-9.6341
3.0	4.67E-05	-9.9708	1.24E-06	-9.6531
4.0	3.79E-05	-10.1813	7.72E-06	-9.7596
5.0	3.04E-05	-10.4019	1.38E-05	-9.8708
6.0	2.25E-05	-10.6999	1.93E-05	-9.9834



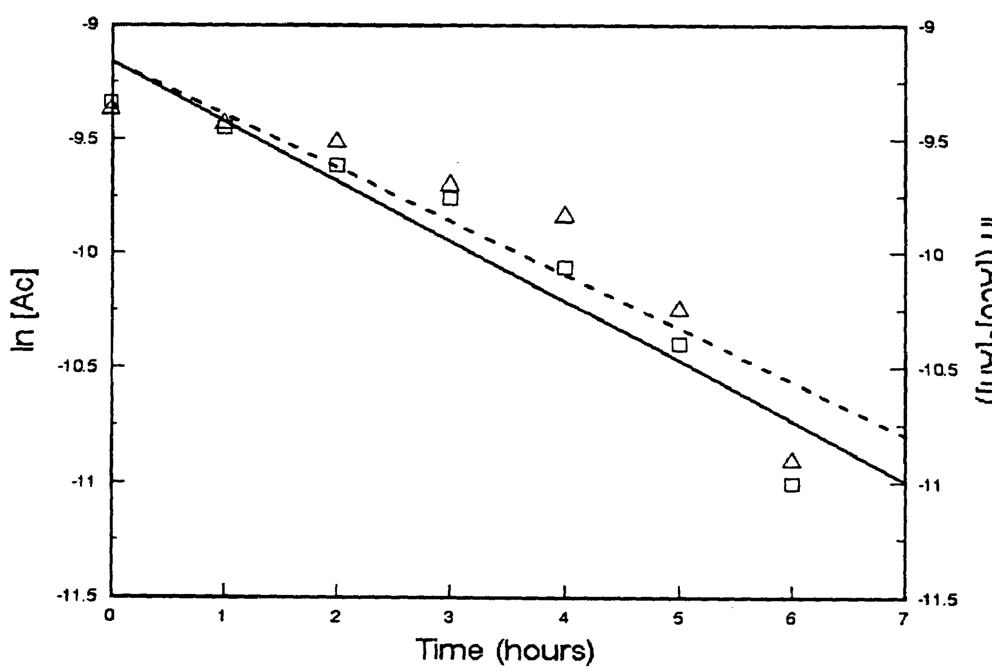
Bacterial Biolysis, Bacillus (B.EPA), p-OCH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 5.26+/-0.66 x 10E-05 sec-1. r = 0.9629, b = -9.438+/-0.086, ssr = 0.0770.				
k obs. (appearance of product) = 1.91+/-0.46 x 10E-05 sec-1. r = 0.8823, b = -9.531+/-0.059, ssr = 0.0377.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	6.64E-05	-9.6195	0.00E+00	-9.6195
1.0	6.85E-05	-9.5892	0.00E+00	-9.6195
2.0	6.56E-05	-9.6327	0.00E+00	-9.6195
3.0	4.72E-05	-9.9615	1.40E-06	-9.6407
4.0	3.85E-05	-10.1660	5.97E-06	-9.7137
5.0	2.96E-05	-10.4264	1.74E-05	-9.9229
6.0	2.36E-05	-10.6523	2.22E-05	-10.0269



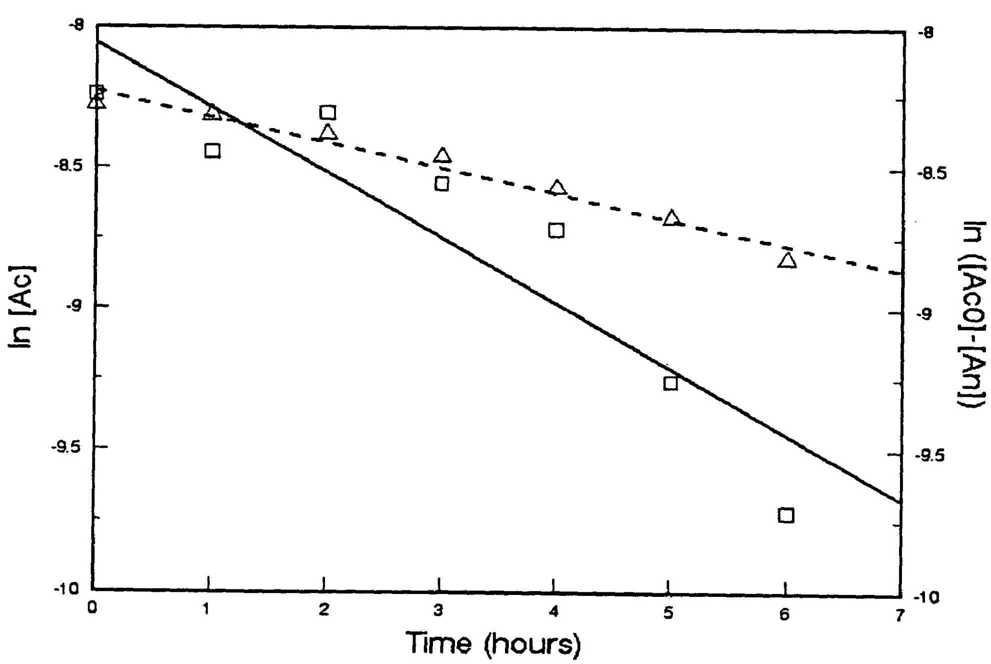
Bacterial Biolysis, Bacillus (B.EPA), p-CH3-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 7.36+/-1.06 x 10E-05 sec-1. r = 0.9516, b = -9.144+/-0.138, ssr = 0.205.				
k obs. (appearance of product) = 5.87+/-0.96 x 10E-05 sec-1. r = 0.9388, b = -9,202+/-0.125, ssr = 0.168.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.74E-05	-9.3451	3.24E-06	-9.3829
1.0	7.99E-05	-9.4351	7.85E-06	-9.4392
2.0	6.87E-05	-9.5864	1.41E-05	-9.5217
3.0	5.82E-05	-9.7521	2.65E-05	-9.7065
4.0	4.49E-05	-10.0115	3.57E-05	-9.8696
5.0	2.98E-05	-10.4204	4.99E-05	-10.1910
6.0	1.64E-05	-11.0206	6.57E-05	-10.7371



Bacterial Biolysis, Bacillus (B.EPA), p-CH3-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 7.28+/-0.99 x 10E-05 sec-1. r = 0.9571, b = -9.161+/-0.128, ssr = 0.176.				
k obs. (appearance of product) = 6.51+/-1.24 x 10E-05 sec-1. r = 0.9203, b = -9.157+/-0.161, ssr = 0.277.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	8.77E-05	-9.3420	2.64E-06	-9.3726
1.0	7.89E-05	-9.4479	7.63E-06	-9.4331
2.0	6.66E-05	-9.6171	1.40E-05	-9.5156
3.0	5.80E-05	-9.7554	2.64E-05	-9.7008
4.0	4.28E-05	-10.0598	3.42E-05	-9.8367
5.0	3.05E-05	-10.3988	5.22E-05	-10.2485
6.0	1.66E-05	-11.0049	6.93E-05	-10.9078



Bacterial Biolysis, Bacillus (B.EPA), p-NO2-acetanilide, replicate 1.				
k obs. (disappearance of reactant) = 6.42+/-1.26 x 10E-05 sec-1. r = 0.9156, b = -8.058+/-0.164, ssr = 0.288.				
k obs. (appearance of product) = 2.52+/-0.21 x 10E-05 sec-1. r = 0.9835, b = -8.231+/-0.027, ssr = 0.00778.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	2.63E-04	-8.2441	9.71E-06	-8.2818
1.0	2.15E-04	-8.4449	1.82E-05	-8.3157
2.0	2.47E-04	-8.3078	3.38E-05	-8.3819
3.0	1.92E-04	-8.5584	5.16E-05	-8.4626
4.0	1.63E-04	-8.7197	7.39E-05	-8.5743
5.0	9.53E-05	-9.2587	9.25E-05	-8.6777
6.0	6.01E-05	-9.7202	1.15E-04	-8.8218



Bacterial Biolysis, Bacillus (B.EPA), p-NO2-acetanilide, replicate 2.				
k obs. (disappearance of reactant) = 6.03+/-1.43 x 10E-05 sec-1. r = 0.8835, -8.151+/-0.185, ssr = 0.370.				
k obs. (appearance of product) = 3.24+/-0.36 x 10E-05 sec-1. r = 0.9710, b = -8.472+/-0.046, ssr = 0.0231.				
t (hrs.)	[Ac ave.]	ln [Ac]	[An ave.]	ln([Aco]-[An])
0.0	2.07E-04	-8.4836	9.97E-06	-8.5330
1.0	2.55E-04	-8.2730	1.97E-05	-8.5837
2.0	2.01E-04	-8.5114	3.09E-05	-8.6456
3.0	1.92E-04	-8.5582	5.08E-05	-8.7654
4.0	1.66E-04	-8.7016	7.48E-05	-8.9327
5.0	8.42E-05	-9.3829	8.48E-05	-9.0111
6.0	6.10E-05	-9.7050	1.12E-04	-9.2598