

HYDROPHOBIC FORCES IN THE STEREOSELECTIVE HYDROLYSES OF
3-NITRO-4-ACYLOXYBENZOIC ACID SUBSTRATES CATALYZED BY
HYDROXAMIC ACIDS

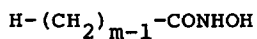
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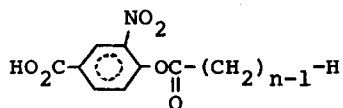
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860

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Although hydrophobic (apolar) forces have recently been observed in the enhancement of the hydrolysis of ester substrates possessing long acyl chain in the presence of poly[4(5)-vinylimidazole] catalyst,¹ polyelectrolytes,² and surfactants,³ an extensive investigation of the hydrophobic interaction between ionic substrate and catalyst, both of which contain different acyl or alkyl chains, seems of interest and significant. We examined 10^{-4} M hydroxamic acid (C_m) catalyzed hydrolysis of 10^{-5} M 3-nitro-4-acyloxybenzoic acid substrate (S_n) with or without micelles of cetyltrimethylammonium bromide (CTAB) at 31.0°C, pH 9.06 in 0.083 M tris(hydroxymethyl)aminomethane buffer ($\mu=0.083$) in H_2O including 10 vol.% CH_3CN . Satisfactory elementary analyses were obtained for the C_m catalysts supplied by the reaction of $H-(CH_2)_{m-1}-CO_2C_2H_5$ ($m=4-10$) and hydroxylamine and for the S_n substrates prepared according to Overberger et al.¹



C_m ($m=4, 6, 8, \text{ and } 10$)



S_n ($n=2, 4, 6, 10, 12, \text{ and } 16$)

The present hydrolysis followed spectrophotometrically by taking notice of phenolate anion formation obeyed a pseudo-first-order rate law, and the second-order rate constant $k_{a,obs}$ being independent on $[C_m]_0$ and $[S_n]_0$ (subscript zero=

Table 1. $k_{a,obs}$ Values for the S_n Hydrolyses by C_m Catalysts

S_n	C_4	C_4+CTAB	r	C_6	C_6+CTAB	r	C_8	C_8+CTAB	r	C_{10}	$C_{10}+CTAB$	r	MHA	MHA+CTAB	r
S_2	26.8	31.7	1.18	25.3	96.7	3.82	27.2	325.0	11.9	31.3	413.1	13.2	40.8	116.4	2.85
S_4	8.3	8.7	1.05	8.6	45.9	5.34	8.8	184.9	21.0	12.2	480.0	39.3	13.2	49.2	3.73
S_6	8.3	7.5	0.90	8.6	33.8	3.93	9.9	190.3	19.2	13.8	497.4	36.0	12.9	50.7	3.93
S_{10}	7.3	6.2	0.85	8.7	30.9	3.55	8.7	143.6	16.5	20.3	298.4	14.7	12.8	43.5	3.40
S_{12}	7.0	5.3	0.76	7.7	28.5	3.70	8.5	145.7	17.1	14.9	346.1	23.2	11.2	39.0	3.48
S_{16}	0.2	5.0	25.0	0.4	25.7	64.3	1.6	156.8	98.0	9.7	312.9	32.3	0.5	36.7	73.4

$k_{a,obs}$ values are in M/sec unit, and r =ratio of $k_{a,obs}$ value in the presence of CTAB to that in its absence.

initial condition) was evaluated as an average value obtained from the reactions repeated three times under the same conditions:

$$k_{a,obs} = (k_{total} - k_{spont}) / [C_m]_0$$

where k_{total} or k_{spont} denotes, respectively, the first-order rate constant for the S_n hydrolysis with or without the C_m catalyst.

The results of a series of the experiments are shown in Table 1, together with those of the S_n hydrolyses catalyzed by a hydroxamic derivative of mandelic acid PhCH(OH)CONHOH (MHA) for comparison's sake. Any substantial contribution of the hydrophobic forces to the hydrolysis acceleration was not recognized in the reactions between the S_n ($n=2 - 16$) substrates and the C_m ($m=4$ and 6) and/or MHA catalysts, and the above catalysts possessing no critical micelle concentrations (c.m.c.)⁴ decreased the $k_{a,obs}$ values monotonically with increasing the acyl chain length in the S_n substrate, probably because long acyl chain resulted in steric hindrance against the reaction.^{1,2} However, it is noteworthy that the C_8 and C_{10} catalysts showing respective c.m.c. around 1×10^{-4} M and 5×10^{-5} M exhibited a selective enhancement of the hydrolysis rates of the S_6 and S_{10} substrates respectively. This presumably implies that the hydrophobic interaction between the micellar C_m ($m=8$ or 10) catalyst and the S_n ($n=6 - 16$) substrate promotes a stereoselective incorporation of S_6 (or S_{10}) by the micelle of C_8 (or C_{10}) possessing the alkyl chain length similar to that in the said substrates.

In the presence of 5×10^{-3} M CTAB detergent (c.m.c.=about 1×10^{-3} M), the micellar catalysis of the detergent was observed in the present hydrolyses which were markedly accelerated by condensing the anionic substrate on the cationic CTAB micelles; The magnitude of the micellar influence on the acceleration of the hydrolysis rate, which can be measured by the ratio of $k_{a,obs}$ in the presence of CTAB to that in its absence, became larger with increasing the alkyl chain length in the C_m catalyst, and not only electrostatic charge attraction but also hydrophobic interaction between the anionic catalyst and the monocationic CTAB contribute to the favorable micelle formation for the system of the micellar C_m ($m=8$ and 10) and CTAB. Such a comicellar catalysis of the C_8 -CTAB or C_{10} -CTAB system selectively enhanced the hydrolysis of S_6 or S_{12} .

respectively, and this is also an interesting phenomenon similar to the case of the C_8 or C_{10} catalyzed hydrolyses of S_n ($n=6$ and 10) without CTAB in terms of the selective acceleration of the hydrolyses of the specified substrates having appropriate acyl chain lengths. In this respect, the C_4 -CTAB system which is incapable of forming comicelles did not enhance the hydrolysis rates of S_n ($n=2 - 12$) only by the aid of the electrostatic interaction between S_n (or C_4) and CTAB, but the comicellar effect of CTAB and S_{16} (c.m.c.=about 1×10^{-5} M) distinguished the S_{16} hydrolysis rate from those of the other substrates in terms of the remarkable enhancement of the reaction.

In conclusion, it can be said that the effective micellar or comicellar catalysis in the hydrolysis of ester substrates is expected through the hydrophobic interaction between catalyst and substrate, both of which contain similar alkyl chain lengths in their frameworks, because, in such a situation, the stereoselective incorporation of the substrate by the micelles or comicelles of catalysts would make the reacting positions of catalyst and substrate close to each other.

References

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- (4) The c.m.c. were measured by the usual conductivity method.