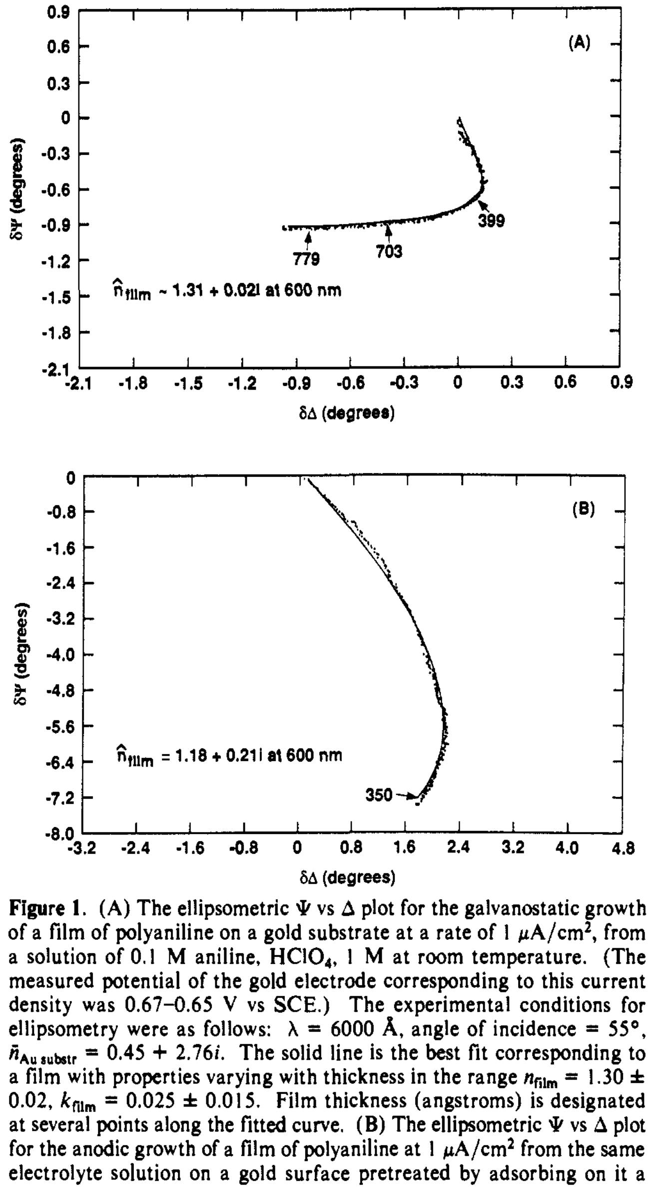

Figure 1. (A) The ellipsometric Ψ vs Δ plot for the galvanostatic growth of a film of polyaniline on a gold substrate at a rate of 1 $\mu A/cm^2$, from a solution of 0.1 M aniline, $HClO_4$, 1 M at room temperature. (The measured potential of the gold electrode corresponding to this current density was 0.67–0.65 V vs SCE.) The experimental conditions for ellipsometry were as follows: λ = 6000 Å, angle of incidence = 55°, $\hat{n}_{\text{Au substr}} = 0.45 + 2.76i$. The solid line is the best fit corresponding to a film with properties varying with thickness in the range $n_{\text{film}} = 1.30 \pm 0.02$, $k_{\text{film}} = 0.025 \pm 0.015$. Film thickness (angstroms) is designated at several points along the fitted curve. (B) The ellipsometric Ψ vs Δ plot for the anodic growth of a film of polyaniline at 1 $\mu A/cm^2$ from the same electrolyte solution on a gold surface pretreated by adsorbing on it a self-assembling monolayer of *p*-aminothiophenol (PATP). The solid line corresponds to the best fit: a film with properties $\hat{n}_{\text{film}} = 1.18 + 0.21i$ (independent of film thickness). Experimental conditions for ellipsometry were the same as in part A. (The gold electrode potential was 0.65–0.64 V.)

characteristic ellipsometric plot shown for this case in Figure 1B is quite different in nature and is associated with a significantly larger radius of curvature. For this film, the optical properties could be fit, assuming no variation with film thickness. The solved imaginary component of the refractive index is 0.21. This means that the absorption coefficient of this film at λ = 6000 Å is about 8 times higher than the average absorption coefficient found for the film grown on "bare" gold. The real part of the complex refractive index is seen to be smaller in the film grown on the PATP-treated surface (1.18 vs 1.30), and this trend has to do with the interrelationship between the real and imaginary components of $\hat{n}_{\text{film}}$, as discussed in detail elsewhere.[8] QCM readings obtained simultaneously for the PANI film grown on the treated surface (Figure 2, solid curve) show that, although this layer is only ca. 400 Å thick, its mass is almost as large as that of the ca. 800 Å thick film grown on "bare" gold. The density calculated for this thinner film varies in the range 1.8–2.1 gr/cm^3, for growth time greater than 50 min. This is a density somewhat higher than expected for a polymer film of this type, even with very good space filling, and we believe that this is caused in part by the perchlorate anions incorporated. However, we cannot rule out the possibility of a slightly underestimated (10–15%) optical thickness. The latter can be caused by some interplay in the fit between optical properties and film thickness, as well as by some lateral nonuniformity of the film within the area probed by the beam.

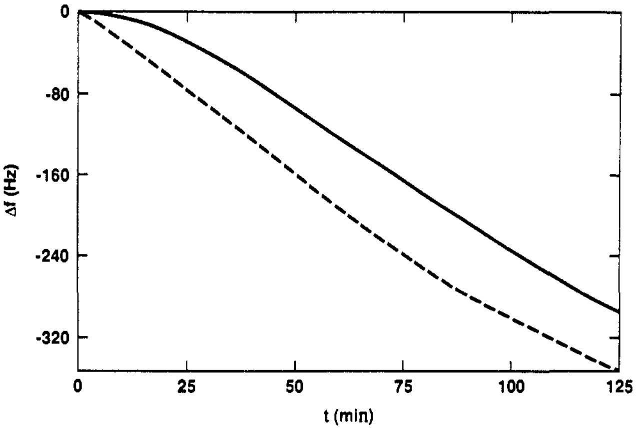

Figure 2. Dashed line: The variation of QCM resonance frequency with time during the growth of the film of polyaniline on the "bare" gold electrode. Solid line: The variation of QCM resonance frequency with time during the growth of the film on gold precovered by a monolayer of PATP. QCM sensitivity = 60 Hz/μg cm^{-2}.

In conclusion, we have shown that a substantial increase in CP film density can be achieved for electrochemically grown PANI films by preadsorbing on the gold electrode surface a self-assembled monolayer of PATP. The PATP molecules bind well to the gold substrate, apparently through the sulfur end,[9] and in turn facilitate and regulate the bonding between the modified surface and the growing phase of the PANI. The beneficial effect obtained on film morphology is apparently caused by a more uniform and efficient nucleation-and-growth process on the treated surface, resulting in a film with signficantly improved space filling. Further work in progress addresses questions of the preservation of the effect of this surface treatment in thicker CP films and the nature of the resulting changes in mechanical, electronic, and electrochemical properties of the CP film.

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Unusual Deacylations: The 2-Acetyl-3-methylbenzothiazolium Cation

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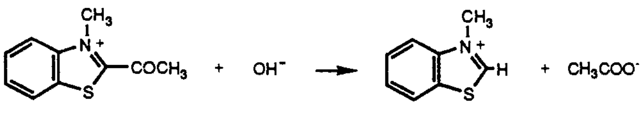
The 2-acetyl-3-methylbenzothiazolium cation undergoes deacylation to acetate and 3-methylbenzothiazolium ions with a second-order rate constant, k^{OH}, close to 10^9 M^{-1} min^{-1}. Despite the reaction being a carbon–carbon bond cleavage, this may be the fastest hydroxide-mediated deacylation yet discovered.



We have reported the unusual deacylation of 2-acetyl-1,3-dimethylbenzimidazolium cation.[1] The rapid carbon–carbon bond cleavage, $k^{OH} = 3 \times 10^6$ M^{-1} min^{-1} ($t_{1/2}$ = 25 s at pH 7.7), is linear with hydroxide from pH 10 at least to pH 4.5 and probably to pH 2. No water reaction is seen. The reaction rate is unaffected,

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moreover, by common good nucleophiles, such as aniline, pyridine, and benzylamine.

Seeking additional examples of such behavior, we have prepared salts of 2-acetyl-3-methylbenzothiazolium, a quaternary cation previously unknown.[2] Like the acetylbenzimidazolium cation, and in marked contrast to other reactive acyl compounds such as *N*-acetylpyridinium ion, *N*-acetoxypyridinium ion, and acetyl chloride, the acetylbenzothiazolium cation is stable toward deacylation by ambient atmospheric moisture, and even toward being dissolved in water as long as the pH is kept low.[3] If the pH is raised even a little, however, deacylation is very rapid indeed. The half-life is less than a minute at pH 5 and a half-second at pH 7. The hydroxide-dependent rate constant is about 1×10^{9} M^{-1} min^{-1} (30 °C, 0.1 M NaCl). Noteworthy, as with the benzimidazolium compound[1] and with the analogous 2-acetyl-3,4-dimethylthiazolium cation,[4,5] is the complete absence of a hydroxide-independent, water-mediated deacylation. The reaction rate is linear with hydroxide from pH 7 at least to pH 3 and probably to pH below 2. Also, again as with the benzimidazole, competing nucleophiles are ignored. No trace of acetanilide is found in reaction mixtures containing aniline, and no significant rate change is seen in buffers (pH 5–6) containing aniline, pyridine, azide ion, or ammonia.

The deacylation is faster than any other hydroxide-mediated deacylations for which we have been able to find rate constants reported. Among carbon–carbon cleavages, diethyl acetylmalonate and diethyl acetylethylmalonate are reported[6] to deacylate with hydroxide constants of 1.3×10^{8} and $\sim 7 \times 10^{7}$ M^{-1} min^{-1}, respectively. Reaction at rates corresponding to these constants is observed only within a narrow pH range (pH 3–4). For both compounds only a pH-independent water reaction is seen below pH 3, and hydration becomes rate-determining above pH 4 so that at neutrality the observed rates are slowed several thousand fold. Published data for the cleavage of nitroacetone[7] can be interpreted to yield a hydroxide rate constant about 1×10^{8} M^{-1} min^{-1} at pH 4–5, but there is no pH–rate study and hence no certainty that this interpretation is valid. Other carbon–carbon cleavages are much slower. For the 2-acetyl-3,4-dimethylthiazolium cation Bruice[4] reports $k^{\mathrm{OH}} = 5.64 \times 10^{6}$ M^{-1} min^{-1} at 30 °C over a wide pH range. A similar value may be deduced from the rate constant of 13.6×10^{6} M^{-1} min^{-1} at 25 °C reported by Lienhard[5] for cleavage of the ketone hydrate. The 2-acetyl derivative of thiamin pyrophosphate cleaves at almost exactly the same rate.[11]

The fastest acyl–X cleavages appear to be those of *N*-acetylpyridinium ions, studied[8] as transient intermediates in the pyridine-catalyzed hydrolysis of acetic anhydride. *N*-Acetyl-4-picolinium ion has $k^{\mathrm{OH}} = 1.6 \times 10^{6}$ M^{-1} s^{-1} (i.e., 1×10^{8} M^{-1} min^{-1}). The k^{OH} for *N*-acetylpyridinium may be double this. Only a narrow pH range was studied. The pH-independent water reaction dominates below pH 4, and there is no data above pH 5. The most reactive acyl–X compound studied directly, the *N*-acetoxypyridinium cation,[9] is some orders of magnitude less reactive, $k^{\mathrm{OH}} = 5.7 \times 10^{5}$ M^{-1} min^{-1}. Data, again, is only for a narrow pH range (9–10), and again the pH-independent water reaction dominates below pH 8. There seems to be no good pH–rate data published for acetyl chloride, but since its hydrolysis is catalyzed by pyridine, it would seem that the spontaneous deacylation must be slower than that of the *N*-acetylpyridinium ion. Other acyl–X compounds such as acetic anhydride and 2,4-dinitrophenyl acetate are much less reactive.

A detailed study of the kinetics and mechanism of hydration and deacylation of the quaternary 2-acetylheterocyclonium ketones is in hand and will be reported soon. For the present, however, the following conclusions appear justified:

1. The hydroxide-mediated deacylations are remarkably fast and reaction is linear with hydroxide throughout a wide pH range.
2. Neither traditional "good" nucleophiles nor water competes with hydroxide, which is to say, no hydroxide anomaly[9,10] is seen.
3. Deacylation rates relate not at all to the quality of the leaving group as indicated by the pK_a of its conjugate acid. The 3-methylbenzothiazolium carbanion (conjugate acid $pK_a \sim 16$) departs 1000 times more readily than pyridine *N*-oxide (conjugate acid $pK_a = 2$), a rate discrepancy, viewed simplistically, in excess of 10^{17}-fold.

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(3) Exposed to atmospheric humidity greater than 80%, the trifluoromethanesulfonate undergoes reversible hydration to *gem*-diol. The chloride hydrate (*gem*-diol) crystallizes from 10% hydrochloric acid and is stable indefinitely. In water at pH below 2, a slow rearrangement occurs with ring expansion to a thiazinone (ref 2). This is without relevance to deacylation, which would have a half-life of some 15 h at pH 2.

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Potent, Broad-Spectrum Inhibition of Glycosidases by an Amidine Derivative of D-Glucose

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Interest in glycoside-cleaving enzymes has been stimulated by the finding that plants and microorganisms produce a variety of monosaccharide-like alkaloids which are potent glycosidase inhibitors.[1] Many such substances have been useful in unraveling how glycosidases catalyze hydrolysis,[2] and some show promise in treating diabetes[3] or as novel antiviral[4] and anticancer[5] agents. Their mode of action is predicated on a generally accepted catalytic mechanism (Figure 1)[6] for enzymes that hydrolyze with retention of configuration. That mechanism involves (a) protonation of the glycosidic oxygen and fragmentation with departure of the aglycon ROH producing (b) a transient, point-charge-stabilized oxocarbonium ion **1** which subsequently collapses to (c) a glycosyl-enzyme intermediate that eventually undergoes hydrolysis at the active site. Protonated inhibitors like 1-deoxynojirimycin (1-dNM) **2** and 1-deoxymannonojirimycin **3** apparently mimic the corresponding gluco- or mannopyranosyl cation.[2,7]

In fact, however, glucose analogue **2** does not resemble the flattened chair conformation of cation **1** particularly well. We now report the first synthesis of (+)-**4**·HCl, the amidine analogue of D-glucose, which combines the correct charge and conformation of glucosyl cation **1**.[8] The sp^2-hybridized anomeric carbons in **4** and its *N*,*N*-dimethyl derivative (+)-**5** also accommodate both the endocyclic nitrogen of 1-dNM and the exocyclic amine group of β-D-glucosylamine, another highly effective glucosidase inhibitor.[9] Besides being a potent inhibitor of β-glucosidase, amidine

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