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ORGANIC ELECTROSYNTHESIS

AMBIDENT SUBSTITUTION REACTIVITY OF CYANO-ALKANES: ELECTROCHEMICALLY-DIRECTED αC-ALKYLATION BY BROMO-ALKANES

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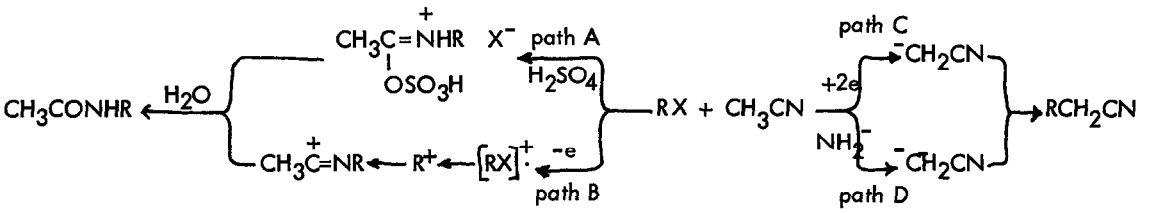
Summary - The formation of N-monoalkylacetamides through the electrolysis of bromoalkanes in cyanoalkanes at 2.35V is largely suppressed at higher electrode potentials in favour of a synthetically more useful αC-alkylation process.

The N-alkylation of cyanoalkanes by carbonium ions is well known, both in its acid-promoted form involving highly-substituted alkenes or tertiary alcohols as reactants (the Ritter reaction;[1] path A in SCHEME), and in its more general electrochemical variant employing halogenoalkanes (path B in SCHEME):[2,3]



SCHEME

Electrochemical acetamidation has been reported for a wide variety of substrates RX, many of these observations arising incidentally as a consequence of the use of acetonitrile as a preferred solvent for organic electrosynthesis. A substantial study[3] of the electrosynthesis of N-monoalkylacetamides from bromoalkanes in acetonitrile containing tetra-ethylammonium tetrafluoroborate (TEAF) or lithium perchlorate has established the intervention of carbonium ion intermediates (path B in SCHEME) when anode potentials of 2.35V are used; yields are ca. 40% with primary bromoalkanes.[3] We now report that this N-alkylation reaction is almost entirely suppressed in favour of the alternative αC-monoalkylation reaction (path C in SCHEME) in the same system at higher electrode potentials (8 - 10V). Representative experimental results for this new homologation process are collected in the TABLE; yields refer to half-completed reactions (1e mole^{-1} bromoalkane).

No di-alkylated cyanoalkane was found, consistent with the more sluggish reaction observed with propionitrile. No isomeric products were formed, in contrast with the mixture of N-alkylacetamides obtained via the carbonium ion pathway,[3] thus suggesting that the α-C-alkylation reaction involves the α-carbanion of the cyanoalkane in a nucleophilic substitution process; the base-mediated equivalent process (path D in SCHEME) is well known.[4] An analogous reaction, the electrochemical addition of the acetonitrile anion to phenyl ketones, has been reported,[5] and here the anion is considered to arise by attack on solvent of an electrochemically reduced unsaturated species formed from the ketone, or from the addition-elimination product PhCR=CHCN. The present results show that a base-free system can also support the electrochemical generation of a cyanoalkane α-carbanion thus opening up a wider range of homologation processes.

TABLE. α-C-Alkylation of Cyanoalkanes[a]

Reactants	Product[b]	Yield (%) of product	Yield(%) of product, allowing for recovered bromoalkane[c,d]	^{1}H NMR data[e,f]
n-$C_5H_{11}Br$, CH_3CN	n-$C_6H_{13}CN$	42	88	0.90t(3H), 1.3-1.5m(8H), 2.35t(2H)
n-$C_5H_{11}Br$, C_2H_5CN	n-$C_5H_{11}CH(CH_3)CN$	10	67	0.93t(3H), 1.85d(3H), 1.1-1.7m(ca 8H), 4.35q(1H)
n-$C_6H_{13}Br$, CH_3CN	n-$C_7H_{15}CN$	41	89	0.91t(3H), 1.51m(ca 10H), 2.35t(2H)

[a] Cyanoalkane solutions 0.6M in bromoalkane, 0.1M in TEAF, Pt wire cathode, Pt sheet anode, electrode potentials ±8-10V w.r.t. Ag/0.1M$AgNO_3$ reference electrode, current 250-300mA, at ambient temperature [b] Structures assigned by mass spectrometry and/or comparison of GLC and ^{1}H NMR data with those of authentic samples [c] 5 to ca 12% N-alkylacetamides were also detected by GLC [d] 2m 15% Apiezon on Chromosorb P at 200°C, 20lb in^{-2} N_2 [e] δ, in C^2HCl_3 [f] For samples isolated from distilled reaction mixtures by prep GLC

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