Potassium 3-Aminopropylamide. A Novel Alkamide Superbase of Exceptional Reactivity

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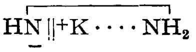
Summary Potassium 3-aminopropylamide, a new, readily prepared superbase, is highly soluble in and stable toward excess amine, extremely reactive in a variety of prototropic processes, and only slightly aggregated even in 1·0 M solution.

ALKALI metal alkamides represent the strongest heteroatom bases known and are exceeded in equilibrium basicity[1] only by metal alkyls. Of these base systems, only the lithium derivatives have found extensive use; heavier metal alkamides are reported far less frequently.

Potassium 3-aminopropylamide (KAPA) is a new, extremely reactive superbase for prototropic reactions with marked advantages over previous systems. It is readily prepared by direct reaction of KH [2] with excess amine, the only by-product being H_2. It is stable toward, and highly soluble ($\geqslant$1·5M) in, excess amine, and shows little decrease in specific activity due to aggregation,[3] even at high concentration. Furthermore, the parent amine is a good solvent for unsaturated and aromatic hydrocarbons, is easily removed from products by acidic or neutral extraction, and is readily available commercially. Finally, examination of models shows that a chelated or internally solvated structure of the amide (I) is highly feasible and is geometrically quite favourable for concerted difunctional mechanisms.[4]


$\underline{HN}^{-}\,\|^{+}K\cdots NH_2$

(I)

The exceptional reactivity of KAPA is readily seen in anionic alkene isomerization[5] and protodedeuteriation.[6] KAPA is 10^5—10^6 times asr eactive as potassium tert-butoxide in dimethylsulphoxide, a system generally used in alkene isomerization; and 10^3—10^4 times as reactive as lithium 2-aminoethylamide [5c,d] in ethylenediamine.† In the exchange of benzene C–D bonds, only caesium cyclohexylamide in cyclohexylamine was comparable in activity; this base is both less soluble and considerably less convenient to prepare. A comparison of properties is listed in the Table.

TABLE

		Relative reactivity	
Base	Solvent	Isomerisation[a]	Exchange[b]
$K^{+-}NH(CH_2)_3NH_2$	$H_2N(CH_2)_3NH_2$	2,300	4,000
$Cs^{+-}NHC_6H_{11}$	$H_2NC_6H_{11}$		4,000[c]
$Li^{+-}NHC_6H_{11}$	$(Me_2N)_3PO$	60[d]	
$Li^{+-}NH(CH_2)_2NH_2$	$H_2N(CH_2)_2NH_2$	1[e]	
$K^{+-}NH_2$	NH_3		50[c]
$Li^{+-}NHC_6H_{11}$	$H_2NC_6H_{11}$		1[c]
$K^{+-}O\text{-}CMe_3$	Me_2SO	0·005[d]	~0[f]

[a] Isomerization of 2,4,4-trimethyl-pent-1-ene (Δ^2 at equilibrium = 18%) at 20° with 0·65–0·70M base. Values derived from $k\psi$. $k\psi$ (KAPA) = $5{\cdot}5 \times 10^{-3}\ s^{-1}$. [b] Exchange of benzene C–D bonds at 20°. Values derived from k_2. k_2 (KAPA) = $8 \times 10^{-2} M^{-1} s^{-1}$. [c] Calculated from ref. 6c—g. [d] Ref. 5a. [e] Calculated from ref. 5d, e. [f] Ref. 6b.

Marked decreases in specific activity of strong bases have been observed as formal base concentration increases; these

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† Ethylenediamine, unlike trimethylenediamine, undergoes complex decompositions in the presence of strong bases, yielding pyrazines.[7] Potassium 2-aminoethylamide, for example, loses *ca.* 50% of its strong base activity in 30 min.

are attributed to association of the active base species‡ into relatively inactive ion-pair aggregates. This phenomenon is of minimal importance in KAPA; correlation of activity with formal base concentration indicates 55—75% free base species (depending upon which association model is operative[3c]) even at 1·0 M total concentration.

The KAPA system is very readily prepared. 25 mmol of KH§ is treated with 20—25 ml of trimethylenediamine (distilled under reduced pressure from barium oxide and stored over 3A molecular sieve) at 20—25°. Hydrogen evolution commences immediately and is quantitative in 15—60 min. The solution produced is yellow but darkens rapidly with even traces of air; the darkening does not appear to affect basicity or reactivity.

In preliminary studies a variety of other strong-base induced reactions have also been carried out at 0—20° using KAPA (Equations 1, 2, 3). These reactions proceeded

$$\text{2-hexyne} \xrightarrow[\text{ii; H}_2\text{O}]{\text{i; KAPA}} \text{1-hexyne} \qquad (1)$$

$$\text{norbornene} + \text{excess } {}^2\text{H}_2 \xrightarrow{\text{KAPA}} [2,3,5,6\text{-}{}^2\text{H}_4]\text{-norbornene} \qquad (2)$$

$$\text{limonene} \xrightarrow{\text{KAPA}} p\text{-cymene} + \text{H}_2 \uparrow \qquad (3)$$

in high yield more rapidly and under milder conditions than any previously reported. The unique combination of properties of KAPA should provide a highly useful tool for both synthetic and mechanistic applications.

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‡ The nature of the active base species is unknown. In the metal cyclohexylamide systems, the monomeric ion pair is considered the active species.[3d,4c,6d]

§ For detailed handling procedures, see ref. 2b.

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