

THE "SUPER-BASIC" BUTYLLITHIUM/POTASSIUM TERT-BUTOXIDE MIXTURE AND OTHER LICKOR-REAGENTS

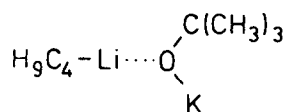
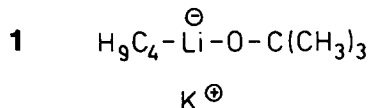
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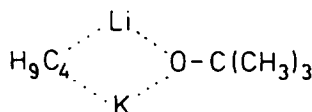
Summary : The reactivity pattern of the butyllithium/potassium tert-butoxide mixture differs significantly from that of butylpotassium and thus disproves the claimed identity of these two reagents.

Potassium *tert*-butoxide activates butyllithium in an unprecedented manner [1]. When treated with this "super base", hydrocarbons in the low-acidity range of pK 35 - 50 undergo a clean hydrogen/metal-exchange : benzene [1], cyclopropane derivatives [2 - 3], cumene [2], a variety of 1- or 2-alkenes having allylic CH-bonds [1, 4 - 9], cyclohexene [2, 10], α -pinene [11], homo-conjugated [7, 12, 13] and conjugated [12] dienes (*e.g.*, 2,4-dimethyl-1,3-pentadiene), α -terpinene (1-isopropyl-4-methyl-1,3-cyclohexadiene) [14], allylsilanes [9], allyl alcohols or ethers [7], allyl thioethers [7], enethers [7], enesulfides [15], 4*H*-pyranes [16] and 1,4-dihydro-pyridines [16].

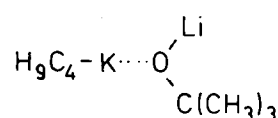
What is, however, the true nature of this "magic metalating mixture" ? Is it an *ate*-complex [17] (1), a symmetrical (2B) or asymmetrical 1 : 1-adduct (2A, 2C) or simply butylpotassium (3) ? Some indirect evidence seemed to advocate for the latter assumption. During their investigations of "Alfin-type" [18] polymerization catalysts Lím and coworkers [19 - 20] concluded that the precipitate which they obtained when stirring a hexane suspension of butyllithium and various potassium alkoxides consisted mainly or exclusively of butyl potassium.



2A

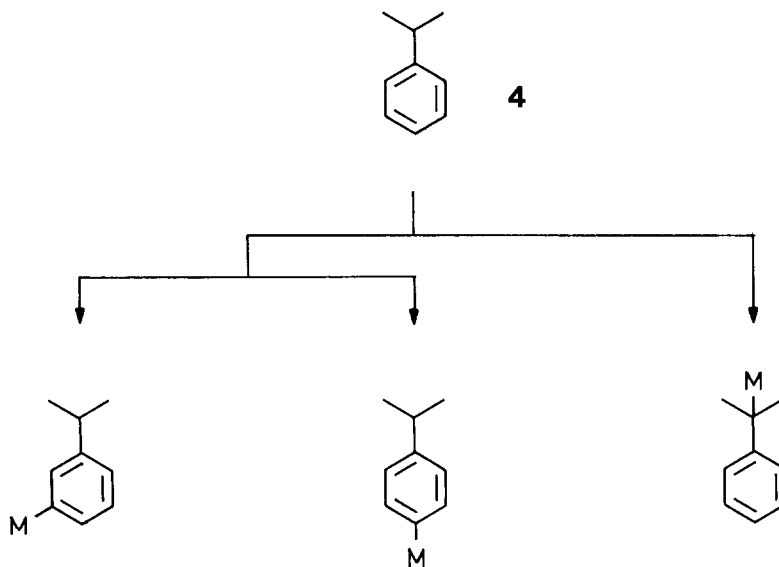


2B



2C

If the "super base" were indeed nothing but butylpotassium, all butyllithium/potassium alkoxide mixtures should behave identically. We prepared a series of such "LICKOR-reagents" ($\text{Li-C}\ddot{\text{C}} + \text{K-OR}$) and probed their individuality using cumene **4** as a model substrate and pentane or tetrahydrofuran (THF) as a solvent. Depending on the nature of the metalating agent the *meta*-, *para*- and benzylic α -position are attacked more or less selectively [21].



Working procedure : reaction times were chosen short enough to keep conversion rates low and to avoid transmetalation [21, 23]. A mixture of cumene, the metalating agent, the alcoholate (3,0 mmol of each) and the solvent (15 ml) were stirred 5 h at 25°C (pentane as the solvent) or 3 h at -50°C (tetrahydrofuran). After quenching with methyl iodide (8,0 mmol, added at -75°C, then 10 h at 25°C), the product composition was analyzed by gas chromatography (55 m glass capillary, Apiezon-L, 130°C; undecane as an "internal standard"). All reactions were run at least 3, some of them up to 6 times. Reproducibility was good (standard deviation : 1 - 2 percentage points) except for the reactions with *sec*-butyllithium where the detailed mode of mixing and the speed of magnetical stirring affect the outcome.

The product composition (M = K and/or Li), determined after quenching with methyl iodide, varied significantly with the metalating agent used, especially in the presence of pentane (see table). The butyllithium/potassium *tert*-butoxide mixture prepared *in situ*, i.e. in the presence of the substrate to be metalated differs both from butylpotassium and from LiM 's precipitates. Moreover, the freshly prepared "super-base" was found to be competitive with all and superior to most other LICKOR-reagents as far as metalating power and selectivity are concerned. Therefore, it should be considered as the first choice whenever a very potent metalating agent is needed.

Table. Metalation of cumene employing alcoholate-activated organolithium ("LICKOR") reagents : yields, ratio of attack at aromatic *vs.* benzylic positions ("a : b") and ratio of attack at *meta*- and *para*-positions ("*meta* : *para*"). a)

LICKOR reagent	solvent : pentane			solvent : tetrahydrofuran		
	yield	a : b	(<i>meta</i> : <i>para</i>)	yield	a : b	(<i>meta</i> : <i>para</i>)
LiCH ₃ /KOC(CH ₃) ₃	2%	58 : 42	(57 : 43)	0%	-	-
LiC ₄ H ₉ /KOC(CH ₃) ₃ ("fresh") ^{b)}	39%	84 : 16	(45 : 55)	16%	95 : 5	(65 : 35)
LiCH(CH ₃)C ₂ H ₅ /KOC(CH ₃) ₃	24%	61 : 39	(57 : 43)	8%	96 : 4	(65 : 35)
LiC(CH ₃) ₃ /KOC(CH ₃) ₃	24%	73 : 27	(57 : 43)	11%	95 : 5	(65 : 35)
LiC ₄ H ₉ /KOCH ₂ C ₂ H ₅	23%	84 : 16	(57 : 43)	3%	97 : 3	(65 : 35)
LiC ₄ H ₉ /KOCH(C ₂ H ₅) ₂	30%	77 : 23	(45 : 55)	10%	88 : 12	(65 : 35)
LiC ₄ H ₉ /KOC(C ₂ H ₅) ₃	34%	85 : 15	(54 : 46)	11%	94 : 6	(65 : 35)
LiC ₄ H ₉ /KON(C ₂ H ₅) ₂	28%	65 : 35	(57 : 43)	3%	97 : 3	(80 : 20)
"LPL precipitate (I [19]) ^{c)}	38%	86 : 14	(45 : 55)	9%	90 : 10	(65 : 35)
"LL precipitate (II [20]) ^{c)}	31%	74 : 26	(51 : 49)	4%	87 : 13	(65 : 35)
KC ₄ H ₉ ^{d)}	14%	69 : 31	(57 : 42)	8%	82 : 18	(65 : 35)
KCH ₂ Si(CH ₃) ₃ [2]	42%	86 : 14	(63 : 37)	45%	1 : 99	(-)

- a) In most cases, if not all, the regioisomeric product composition was checked as a function of the metalation time. In pentane all a : b ratios turned out to be time-variant. Typically it decreased from, say, 85 : 15 at the very beginning to 70 : 30 after 8 h. In the presence of potassium dimethylamine or an excess of potassium *tert*-butoxide even smaller ratios (60 : 40) were observed. Butyllithium in both, pentane and THF, produced initially a 95 : 5 mixture and approached a 70 : 30 ratio after 8 h. All other reactions in THF were found to be time-invariant except when the alcoholate was applied in substantial excess.
- b) Almost identical results were obtained with potassium 1,1-dimethylpropoxide ("*tert*-amylate") instead of potassium *tert*-butoxide.
- c) Butyllithium and potassium *tert*-butoxide or potassium mentholate (prepared from laevorotatory menthol and KH in diethyl ether), 3,0 mmol each, were mixed in 15 ml pentane, which was stirred 1 h at 0°C. Precipitates I and, respectively, II formed immediately. When THF was used as a solvent, most of the pentane (roughly 10 ml) was syphoned off beforehand. Lím et al. [19, 20] had restricted their work to suspensions in petroleum ether fractions.
- d) Prepared from dibutylmercury [24].

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- [23] Under the chosen reaction conditions the time dependence of a : b ratios was small in the case of pentane suspensions and negligible in the case of THF solutions (see also table footnote a). An excess of potassium *tert*-butoxide, however, was found to catalyze the transmetalation efficiently, converting isopropylphenyl potassium to α -cumyl potassium.
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