Tetrahedron Letters No. 2, pp 183 - 186, 1977. Pergamon Press. Printed in Great Britain.

REACTIONS OF ORGANIC ANIONS. LXXIII. ALKYLATION OF PHENYLACETONITRILE AT THE INTERFACE WITH AQUEOUS SODIUM HYDROXIDE

M.Mąkosza and E.Białecka

Institute of Organic Chemistry and Technology
Technical University (Politechnika), 00-662 Warsaw, Poland

(Received in UK 18 November 1976; accepted for publication 29 November 1976)

A catalytic two-phase method of generation of carbanions and halocarbenes employing as a base concentrated aqueous NaOH in the presence of catalysts (usually tetraalkylammonium salts, Q^+X^-) is now well recognized and widely applied in organic synthesis[1,2]. The term "phase-transfer catalysis" generally accepted for this procedure implies that the catalyst e.g. Q^+Cl^- is converted into Q^+OH^- and the latter acts as the base in the organic phase[3]. Interfacial reactions are usually neglected[4].

In our opinion, however, carbanions are formed at the interface upon the action of aqueous sodium hydroxide on C-H acids, then the carbanions form organic phase soluble ion-pairs with cations supplied by catalysts[1a]. We have already shown that reactions of some carbanions with active electrophiles can occur in this two-phase system without a catalyst, the process being apparently interfacial[1a,5a]. Also dichlorocarbene is able to enter some reactions at the interface[5b]. Now we would like to show that also alkylation of phenylacetonitrile (PAN) can take place on the phase boundary.

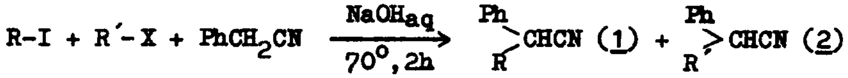
Alkyl iodides R-I cannot be used as alkylating agents in a typical two-phase catalytic system since Q^+I^- dominates over $Q^+\ \bar{C}\!<$ in the organic phase[6]. Being however considerably more active than other alkyl halides, they are able to alkylate PAN when both these substances are stirred with concentrated aqueous NaOH at elevated temperature (60-80°). For instance stirring PAN with BuI and

50 % aqueous NaOH at 80° for 5 hrs results in ~ 70 % of alkylation. Since there is no catalyst in the system we believe that the processes (the formation of the carbanion and its alkylation) occur at the interface. One of the evidences that the process is virtually interfacial is negligible mutual solubility of these both phases. By the colorimetric method based on a colour reaction with p-dinitrobenzene the concentration of phenylacetonitrile in the aqueous phase was found to be below 2 ppm, whereas the concentration of phenylcyanomethide in the organic phase - around 5 ppm (as the total concentration of sodium by flame photometry). The analytical data show that the reaction cannot proceed in either of the phases, therefore it should proceed at the interface.

A more suggestive evidence which reveals the importance of the interfacial processes comes from the competitive alkylation of PAN with various alkyl halides.

Although under the above described conditions alkyl bromides and benzyl chloride (R′-X) do not react with phenylacetonitrile, use of the 1:1 mixture R′-X with R-I leads to the formation of two alkylated products $\underline{1}$ and $\underline{2}$ (Table). Product $\underline{2}$ is obviously formed via R′-I, the latter resulting from halogen exchange of R′-X with sodium iodide produced from R-I during the formation of $\underline{1}$.

Table



$$\text{R-I} + \text{R}'\text{-X} + \text{PhCH}_2\text{CN} \xrightarrow[70^\circ,\,2h]{\text{NaOH}_{aq}} \overset{\text{Ph}}{\underset{\text{R}}{>}}\text{CHCN}\ (\underline{1}) + \overset{\text{Ph}}{\underset{\text{R}'}{>}}\text{CHCN}\ (\underline{2})$$

	1	2	3	4	5	6	7	8	9	10	11	12
R-I	BuI	-	BuI	-	BuI	BuI	BuI	PrI	-	PrI	-	PrI
R′-X	-	PrBr	PrBr	$PhCH_2Cl$	$PhCH_2Cl$	-	AllCl	-	BuBr	BuBr	$PhCH_2Cl$	$PhCH_2Cl$
yield $\underline{1}$	10	-	11	-	18	4.5	10	5.1	-	5.1	-	1.5
% yield $\underline{2}$	-	0^{*}	1.5	0.5^{*}	10	-	5	-	-	2.7	0.5	9.3

Experiments No 6 and 7 were carried out at 50°, 8-12 on motionless interface without stirring (70°, 70 hrs). When one alkylating agent was used the organic layer was diluted with toluene in order to have the constant volume.

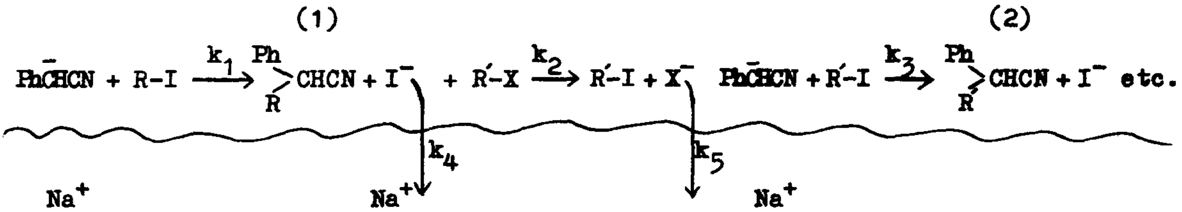
[*] Addition of sodium iodide has not increased the yield.

However in separate experiments it was shown that there is no exchange $R'{-}X \longrightarrow R{-}I$ with sodium iodide added to the system.

These results show that I^- formed during the alkylation at the interface (roughly speaking on the organic side of the phase boundary) react with $R'{-}X$ giving new alkyl iodides $R'{-}I$ capable to alkylate PAN, whereas those I^- introduced to the aqueous phase with NaI do not.

Therefore the rate of the transfer of I^- anions "through the phase boundary" should be moderate, lower or comparable with the rate of the halogen exchange.

The situation can be visualized on a oversimplified scheme



$$k_1 \lessgtr k_3 \text{ depending on } R'; \quad k_2 > k_4; \quad k_5 > k_4$$

It should be also mentioned that the total degree of alkylation of PAN with a mixture of R-I and $R'{-}X$ is higher then the alkylation with the single R-I. This can be rationalized by the assumption that I^- ions located "on the organic side of the phase boundary" competing with carbanions decrease the rate of the alkylation. The reaction $R'{-}X + I^- \longrightarrow R'{-}I + X^-$ results in replacing of I^- with X^-; the later pass to the aqueous phase faster than I^- ($k_5 > k_4$), thus the above mentioned inhibiting effect of I^- is eliminated.

Additional arguments supporting these suppositions appear when we compare the results of experiments in which the reaction mixtures were stirred with those carried out without stirring (constant, motionless interface). The latter conditions disfavour difussion, thus $R'{-}I$ formed at the interface participated in the alkylation to greater extent than it could be expected considering activities of $R'{-}I$ and R-I and their concentrations in the organic phase.

These results show that interfacial phenomena are of crucial importance during the two-phase alkylation of carbanions.

References

1. a. M.Mąkosza, Pure and Applied Chemistry, 43, 439 (1975); b. M.Mąkosza and A.Jończyk, Organic Syntheses, Vol. 55, 43.
2. a. J.Dockx, Synthesis, 1973, 441; b. E.V.Dehmlow, Angew.Chem., 86, 187 (1974), Internat.Ed.Engl. 13, 170 (1974), Chem.Tech. 1975, 210.
3. For instance H.Iida, N.Ooki, K.Takahashi and K.Yamada, Nippon Kagaku Kaishi, 1974, 2127, C.A. 83, 27739 (1975); R.K.Singh and S.Danishefsky, J.Org.Chem., 40, 2969 (1975)
4. Recently, however F.Menger, J.U.Rhee and H.K.Rhee, J.Org.Chem., 40, 3803 (1975) and F.Yamashita, A.Atsumi and H.Inoue, Nippon Kagaku Kaishi, 1975, 1102, C.A. 83, 113378 (1975) have shown that even typical phase-transfer processes are interfacial to a great extent.
5. a. A.Jończyk, Bull.Acad.Polon.Sci., ser.sci.chim., 22, 849 (1974), A.Jończyk, K.Bańko and M.Mąkosza, J.Org.Chem., 40, 266 (1975); b. M.Mąkosza, M.Fedoryński and A.Kacprowicz, Tetrahedron Letters, 1975, 2119.
6. M.Mąkosza and B.Serafin, Roczniki Chem., 39, 1223 (1965)