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Hydrogen Bond Assisted Organic Reactions: *C*- and *O*-Alkylations, Sulphenylations, and Michael Additions Aided by Polymer Immobilized Fluoride Ion

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Summary Hydrogen bond assisted *C*- and *O*-alkylations, sulphenylations, and Michael additions have been carried out with the aid of fluoride ion immobilized on strongly basic anion exchange resins.

WE have previously shown the utility of alkali metal fluorides or tetra-alkylammonium fluorides in strong hydrogen bond assisted reactions leading to *C*-alkylation,[1] *O*-alkylation,[2] sulphenylations,[3] and Michael additions.[4] In recent years functionalized insoluble polymers have been developed for a variety of sequential and simple one-step organic syntheses[5] including a number of alkylations[6] and fluorinations,[7] the latter demonstrating one use of the fluoride form of an ion exchange resin. We have therefore attempted to use commercial, strongly basic anion exchange resins, converted into their fluoride form, to carry out reactions analogous to the strong H-bond assisted reactions described.[1-4]

Preliminary studies showed that analytical grade ion exchange resins such as Amberlite, IRA-400, and Dowex 1X-8 were unsuitable. Low cross-linkage analytical resins such as Dowex 1X-2 were no better. However, Dowex MSA-1 macroporous resin and Amberlyst A26 and A27 macroreticular resins (the latter two designed for use in non-aqueous media) gave encouraging results (Table). *C*- and *O*-alkylations, sulphenylations, and Michael additions were

TABLE

Reactants	Product	Time (h)	Temp. (°C)	Solvent	Yield (%)	Resin (F^- form)
C-Alkylation						
$[MeC(O)]_2CH_2 + MeI$	$(MeC)_2CHMe$	48	60	DMF	70	Dowex MSA-1
"	"	24	20	THF	0	"
"	"	24	20	THF	60	Amberlyst A26
"	"	24	20	THF	70	Amberlyst A27
O-Alkylation						
$PhOH + MeI$	$PhOMe$	24	60	DMF	50	Dowex MSA-1
$p\text{-}NO_2C_6H_4OH + MeI$	$p\text{-}NO_2C_6H_4OMe$	24	60	DMF	50	"
Sulphenylation						
$[MeC(O)]_2CH_2 + PhSH + \text{air}$	$[MeC(O)]_2CH(SPh)$	24	60	DMF	75	"
$[MeC(O)]_2CH_2 + Ph_2S_2$	"	24	60	DMF	75	"
Michael addition						
$MeC(O)CH{=}CH_2 + PhSH$	$MeC(O)CH_2CH_2SPh$	24	20	THF	80	"

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observed in reactions analogous to those carried out in homogeneous systems. Fluoride ion is a necessary ingredient. No reaction was observed in control experiments with the reagents in the absence of resin, or if the chloride form of the resin was used. No attempt has been made as yet to determine the optimum solvent, time, or temperature or means of freeing the resin of all traces of product to improve yields. In the one series of *C*-alkylation reactions, in which we compare the MSA-1, A-26, A-27 resins, it would appear that the Amberlyst resins, in particular the A-27, are the resins of choice. At room temperature in tetrahydrofuran (THF), the MSA-1 showed no *C*-alkylation reaction. The Amberlyst resins also showed less physical breakup than the Dowex, while being stirred in the reaction flask. The preliminary experiments show that it is possible, after use, to regenerate the resin to its F^- form and reuse it for subsequent reactions. Yields, however, appear to be slightly lower, but no attempt has been made to optimize the regeneration conditions.

The F^- resin was prepared from the Cl^- form of the commercial resins by first converting into the hydroxy form and then treating the hydroxy form with either HF or KF solutions. Resins were washed with methanol and acetone and dried under vacuum at room temperature.

In a typical reaction, a solid solvate was formed with the resin by adding acetylacetone (0·01 mol) to the resin (0·012 mol F^-) and then pumping off any liberated water or unchanged acetylacetone. The solvent [30 ml of dimethylformamide (DMF) or THF] was then added along with methyl iodide (0·01 mol) and the resulting mixture was stirred at 20 °C for 24 h prior to separation of the resin and workup of the products in a standard manner.

It is clear, therefore, that anion exchange resins containing fluoride ion are powerful bases for promoting many base catalysed organic reactions under mild conditions that do not induce unwanted base catalysed polymerizations. The systems offer a convenient means of removing one of the products in a form suitable for regeneration of starting reagent (F^- resin). As we have shown previously, for many 'base catalysed' reactions, the yield is improved if F^- is present not as a catalyst, but in a 1 : 1 ratio with the reagent capable of forming a strongly hydrogen-bonded solvate.

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