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ALKALINE FLUORIDE-*m*-CHLOROPEROXYBENZOIC ACID SYSTEMS AS MODULATED OXIDATION REAGENTS: EPOXIDATION OF α,β-UNSATURATED ACETALS

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High yields (80-96%) of epoxides of α,β-unsaturated acetals can be obtained by the use of suitable KF:NaF:*m*-CPBA mixtures as modulated oxidation reagents.

Recently, we have reported that an insoluble 1:2 *m*-CPBA:KF system is an improved reagent for the preparation of acid labile epoxides, such as α-methylstyrene oxide.[1,2] The strong interaction induced by this fluoride originates the formation of a contradictory *epoxidation solid-phase reagent*, in which the advantageous elimination of all the acid moieties from the reaction media is counterbalanced by an undesirable increase of the decomposition rate of the peroxyacid with a concomitant partial waste of the active oxygen content.[2] Consequently, we anticipated that further improvement of our reagent could be achieved by modulation of the above interaction changing the ionic character of the fluoride used. In the present communication we report our preliminary results on this regulation with NaF.

When a 100% molar excess of NaF (commercial grade reagent (99.5%) was used without further purification or activation) was added to a CH_2Cl_2 solution of *m*-CPBA, no insoluble complex was formed in this case, and stability of the peroxyacid was almost unaffected (<5% loss of active oxygen after 24 h at r.t.). Epoxidation of α-methylstyrene with this system under the same reaction conditions as those used for the *m*-CPBA:KF complex (20 h at r.t., followed by removal of all *m*-CPBA and *m*-CBA by precipitation with KF) resulted in a quantitative conversion of the starting olefin to afford a reaction mixture which contained only 60% of α-methylstyrene oxide. This yield was lower than that obtained with the *m*-CPBA:KF complex (90%),[2] but higher than the one reported by using the conventional procedure (20%).[3] On the other hand, when the *m*-CPBA:NaF system was used, the reaction time could be shortened to 75 minutes, increasing the yield of α-metyhl-styrene oxide up to 90%. Comparable results were also obtained using LiF. In both cases the significant change in reaction rate was accounted for the increased solubility of the peroxyacid, allowing the reaction to take place essentially in an homogeneous phase.

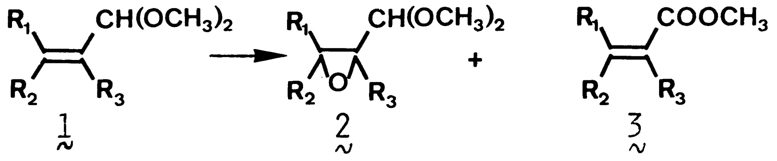
These results showed that the assumed modulation of our oxidation system was feasible provided that a compromise among fluoride interaction with the acids in solution, fluoride-bonded acids in insoluble form and peroxyacid decomposition could be reached.

In this context, we explored the application of this modulated reagents to the epoxidation of α,β-unsaturated acetals. To our knowledge, the only precedent in the literature for this reaction is the work of Heywood and Phillips,[4] in which treatment of cyclic acetals with peroxyacetic acid afforded the desired epoxides in 28-67% yields, whereas in the case of acyclic acetals the predominant products of oxidation, under these conditions, were the corresponding unsaturated esters.

The results of our study on the epoxidation of different acyclic acetals are summarized in the Table 1. Reaction of crotonaldehyde dimethyl acetal with the insoluble 1:2 *m*-CPBA:KF complex under the standard conditions (15 h at r.t. in CH_2Cl_2), gave a poor conversion (< 10%, Entry 2), which was increased up to 48% by a 25% reduction of the KF molar amount in the system (Entry 3). This conversion increment could be accounted for by the partial release of peroxyacid to the solution under these conditions. Nevertheless, the "free" acids should be still interacting with the fluoride ion as can be inferred by comparison of the above results with the complex mixtures obtained in absence of fluoride (Entry 1).

On the other hand, when the 1:2 *m*-CPBA:NaF system was used, all starting olefin was consumed and ^{1}H NMR analysis of the crude reaction mixture revealed the presence of the corresponding epoxide and methyl crotonate in a 64:36 molar ratio, accompanied by a small proportion of crotonaldehyde (Entry 4). As shown in Entries 5-10, modulation of the oxidation system by a suitable molar combination of NaF and KF led to obtain the desired epoxides in good to excellent yields, minimizing the formation of side products. It is worth to point out that in the case of α,β,β-trisubstituted olefins (Entries 9 and 10), an accurate optimization of the

TABLE 1. Epoxidation of α,β-unsaturated acetals with alkaline fluorides-*m*-CPBA systems.



Entry		1		KF:NaF:*m*-CPBA molar ratio	2	3
	R_1	R_2	R_3		%	%
1	H	CH_3	H	0 : 0 : 1	-[a]	-[a]
2	H	CH_3	H	2 : 0 : 1	<10[b]	-
3	H	CH_3	H	1.5 : 0 : 1	48[b]	-
4	H	CH_3	H	0 : 2 : 1	58	32[c]
5	H	CH_3	H	0.5 : 1.5 : 1	80	10
6	H	Ph	H	0.5 : 1.5 : 1	88	11
7	H	H	CH_3	0.5 : 1.5 : 1	92	-
8	H	C_2H_5	CH_3	0.5 : 1.5 : 1	94	-
9	CH_3	CH_3	H	0.5 : 1.5 : 1	72	14[c]
10	CH_3	CH_3	H	0.8 : 1.2 : 1	96	3

a) Complex mixtures were formed and no epoxide was detected.

b) Starting material accounted for the remaining percentage

c) A small amount of the corresponding α,β-unsaturated aldehyde was also identified.

molar ratio of both fluorides became crucial for attaining satisfactory results.

These preliminary data have shown the usefulness of this new modulation concept in oxidation reactions and have encouraged us to explore the scope of these systems to other synthetic targets, which is now under active research.

Standard Procedure

Reactions were carried out by addition of the olefin (13 mmol) to the corresponding *m*-CPBA:fluoride system (see Table 1) in CH_2Cl_2 (80 ml). After stirring for 15 h at r.t., activated KF (1 h at 120 °C/0.1 Torr) was added up to a total 1:2 *m*-CPBA:KF molar ratio and the crude reaction mixture was stirred for 1 h at r.t.; then the crude mixture was filtered off and the solvent was removed under reduced pressure to afford a residue which contained the expected epoxide. Yields depicted in the Table 1, unless otherwise stated, are based on the recovered crude residue and the ^1H NMR estimation of the epoxide or the ester content. All new compounds were fully characterized by their correct elemental analyses and their satisfactory ^1H NMR and IR spectra.

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References

1) F. Camps, J. Coll, A. Messeguer, and M.A. Pericàs, Tetrahedron Lett., 1981, 3895.
2) F. Camps, J. Coll, A. Messeguer, and F. Pujol, J. Org. Chem., 47, 5402 (1982).
3) C.R. Harrison and P. Hodge, J. Chem. Soc., Perkin Trans. 1, 1976, 605.
4) D.L. Heywood and B. Phillips, J. Org. Chem., 25, 1699 (1960).

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