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Short Communication

Ionic Liquids as Reagent and Reaction Medium: Preparation of Alkyl Aryl Ethers

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Summary. Room temperature ionic liquid, [*bmIm*]OH, is used as a green recyclable reaction medium and reagent for the alkylation of phenols in excellent yields. The recovered ionic liquid was reused five to six times with consistent activity.

Keywords. Alkylations; Catalysts; Phenols; Ethers; Green Chemistry.

Introduction

Preparation of alkyl aryl ethers is an important synthesis reaction for which a wide variety of procedures has been developed during the last hundred years [1, 2]. Most of the commonly used methods involve alkylation of the parent phenol or derived phenoxide ion, with the latter being by far the more important.

O-Alkylated phenols produced by regioselective synthesis belong to an extremely attractive domain in organic chemistry. One possible way of accomplishing the O-alkylation is by using a stoichiometric amount of a strong base. The established methods include the use of alkali metal hydroxides [3], alkali metal hydrides [4], and phase-transfer catalytic conditions [5, 6].

Phenoxides undergo O-alkylation in solvents, such as *DMSO*, *DMF*, ethers, and alcohols. In water and trifluoroethanol, however, extensive C-alkylation occurs [7, 8]. These latter solvents form particularly strong hydrogen bonds with the oxygen atom of the phenolate anion. This strong solvation decreases the reactivity at the oxygen and favors C-alkylation.

Though some of the above-mentioned methods provided good yields of alkyl aryl ethers, they also involve the use of hazardous and carcinogenic dipolar aprotic

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organic solvents. Moreover, during the workup these solvents are converted into waste byproducts, making their recycling impossible. Further, some of the above-mentioned bases are flammable. Thus, the development of an efficient, safe, and environmentally friendly method of phenol O-alkylation constitutes an important challenge.

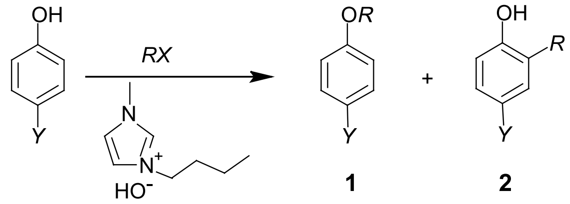
In recent years, ionic liquids (ILs) [9] have attracted extensive interest as environmentally friendly solvents due to their favorable properties, such as non-flammability, negligible vapor pressure, reusability, and high thermal stability [10]. Over the past few years, a variety of catalytic reactions has been successfully conducted using ILs as an alternative for organic solvents [11, 12]. Especially, one of the advantages of ILs is their behavior as an acid or base catalyst. Recently, *Ranu* and *Banerjee* [13] reported the dramatic influence of a new tailor-made, task-specific, and stable ionic liquid, 1-butyl-3-methylimidazolium hydroxide [*bmIm*]OH, in *Michael* additions.

In our quest to develop a general method for the O-alkylation of phenols we now discovered that [*bmIm*]OH efficiently promotes this reaction without any additional catalyst and solvent.

Results and Discussion

A number of different phenols and alkyl halides were subjected to the alkylation reaction to test its generality, and the results are summarized in Table 1. The results

Table 1. Preparation of alkyl aryl ethers



Entry	*Y*	*R*	*X*	Yield		
				%[a] **1**	%[b] **1**	%[b] **2**
1	H	benzyl	Br	92	100	0
2	H	4-nitrbenzyl	Br	95	100	0
3	H	4-methylbenzyl	Br	80	99	1
4	H	4-chlorobenzyl	Br	83	100	0
5	H	benzyl	Cl	80	97	3
6	NO_2	benzyl	Br	95	100	0
7	CH_3	benzyl	Br	82	94	6
8	H	ethyl	Br	70	96	4
9	H	2-propyl	Br	44	100	0
10	H	ethyl	I	80	100	0
11	H	ethyl	Cl	65	96	4
12	Cl	ethyl	I	87	99	1

[a] Isolated yield; [b] GC yield

indicate that deactivated phenols are more active and selective for O-alkylation (Entry 6). Introduction of an electron-donating substituent on the aromatic ring substantially decreases the reaction rate (Entry 7). Alkyl iodides react more readily than bromides, with chlorides being still less reactive.

In conclusion, the present procedure using a basic ($pH = 9.3$) and easily available ionic liquid [*bmIm*]OH provides an efficient and convenient procedure for the O-alkylation of phenols without requiring any other base and organic solvent. This method offers marked improvements with regard to operational applicability, high isolated yields of products, and greenness of procedure, avoiding hazardous organic solvents and toxic catalysts, and thus, it provides a facile and practical procedure for the preparation of alkyl aryl ethers. In addition, it turned out that [*bmIm*]OH could be reused up to six times after recovery with unchanged activity.

Experimental

Yields refer to pure isolated products. All compounds are known and were characterized by comparison of their physical and spectroscopic data with those of authentic samples. The IL [*bmIm*]OH was prepared according to Ref. [13].

Preparation of Alkyl Aryl Ethers

Alkyl halide (10 mmol) was added to a mixture 10 mmol phenol in 10 mmol [*bmIm*]OH at 70 °C, and the reaction mixture was stirred for 2 h until completion of reaction (TLC). The reaction mixture was extracted with 15 cm^3 ethyl acetate. The extract was washed with 5 cm^3 H_2O, dried, and evaporated. The crude product was purified by column chromatography over silica gel providing the pure product (Table 1). The ionic liquid left in the reaction vessel was mixed with 10 cm^3 ether containing 1% HBr, decanted, and heated at 80 °C under vacuum for 30 min. The resulting ionic liquid, 1-butyl-3-methylimidazolium bromide, was converted to the base according to Ref. [13]. The recovered ionic liquid was reused six times with consistent activity.

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