Bifunctional Ionic Liquids Derived from Biorenewable Sources as Sustainable Catalysts for Fixation of Carbon Dioxide

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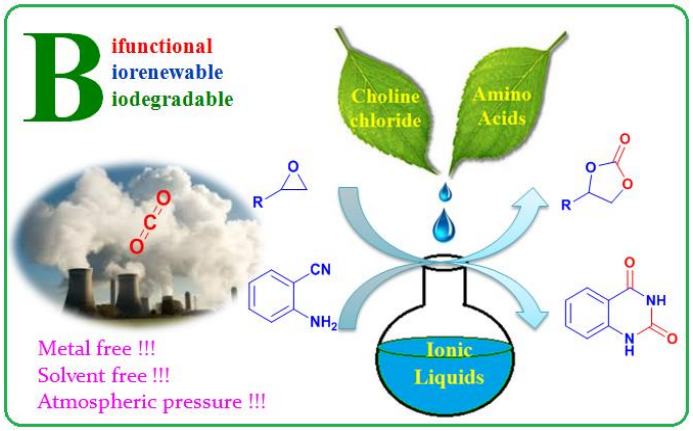
Abstract: A series of highly efficient, bifunctional ionic liquids containing a quaternary alkyl ammonium cation and an amine anion were prepared from choline and amino acids, respectively. Nine ILs were synthesized, characterized, and applied as organocatalysts for the chemical fixation of carbon dioxide to form cyclic carbonates and quinazoline-2,4(1H,3H)-diones. A binary mixture of an IL and a co-catalysts generates deep eutectic solvents (DESs) and accelerates the rate of the cycloaddition reaction at atmospheric pressure and low temperature (70 8C). The presence of the hydroxyl functional group of choline and the free amine group of the amino acids in the ILs has a synergistic effect on the activation of the epoxide and carbon dioxide towards the cycloaddition reactions. These ILs are biodegradable and are synthesized from easily available biorenewable sources. Additionally, this catalytic method demonstrates ultimate environmental benignity because of the mild metal- and solvent-free conditions as well as the recyclability of the catalyst and co-catalyst.

Keywords: Carbon dioxide , Catalysis , Sustainable synthesis.

1. Introduction

The increased concentration of carbon dioxide in the atmosphere is an environmental threat and an important burning issue in our society. Carbon dioxide is kinetically and thermodynamically stable, but the utilization of carbon dioxide as a chemical feedstock provides interesting organic structures with high atom economy.[1] Among these, carbonates are important as they can be used in various applications, including additives in fuel, aprotic solvents, monomers in polymeric structures, electrolytes in secondary batteries, and raw materials in various reactions.[2] In the past decades, numerous catalytic systems have been developed for the catalytic fixation of carbon dioxide such as metal–salen complexes,[3] metal oxides,[4] N-heterocyclic carbenes,[5] N-heterocyclic olefins,[6] and Schiff bases.[7] However, most of the catalytic systems suffer from one or more disadvantages such as low catalytic stability and reactivity, use of co-solvents, use of transition metals, harsh reaction conditions, catalyst degradation, and complicated methods for the synthesis of the catalysts.



Scheme 1. Fixation of carbon dioxide in to the value added chemical by using the sustainable catalysts.

Conclusions

A simple, sustainable, cost-effective, and energy-efficient protocol has been developed for the chemical fixation of carbon dioxide into cyclic carbonates as well as quinazoline-2,4(1H,3H)-diones using choline- and amino-acid-based ionic liquids (ILs). The binary system based on [Ch][AA]/TBAI generated deep eutectic solvents (DESs), which were found to be highly active for the catalysis of the cycloaddition of carbon dioxide with epoxides at atmospheric pressure. These catalysts can effectively activate epoxides through a synergistic effect of a hydroxyl group at the choline cation and carbon dioxide at the amine anion of the amino acids. The catalyst and the co-catalyst are both recyclable up to five cycles without loss of catalytic activity. Additionally, the ILs were synthesized from environmentally friendly starting materials that are highly biodegradable and have negligible toxicity, which is a promising for the fixation of carbon dioxide.

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