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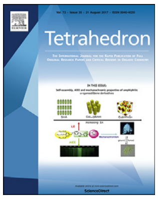

# Polyethylene glycol methacrylate-grafted dicationic imidazolium-based ionic liquid: Heterogeneous catalyst for the synthesis of aryl-benzo[4,5]imidazo[1,2-*a*]pyrimidine amines under solvent-free conditions

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ABSTRACT

A novel polyethylene glycol methacrylate-grafted tetra-ethylene glycol-bridged dicationic imidazolium-based ionic liquid (PEGMA-g-TEGBDIM) was prepared by grafting tetra-ethylene glycol-bridged 1-vinyl imidazolium mesylate to the surface of cross-linked polyethylene glycol methacrylate. Its structure was characterized by FT–IR, NMR, TGA, and XPS. Due to the combination of polymer-supports and flexible imidazolium linkers, it acted as a heterogeneous catalyst to exhibit excellent catalytic activity for the efficient synthesis of *N*-methyl-2-nitro-aryl-benzo[4,5]imidazo[1,2-*a*]pyrimidine amines *via* the multicomponent reaction of 1*H*-benzo[*d*]imidazol-2-amine (**1**) and (*E*)-*N*-methyl-1-(methylthio)-2-nitroethenamine (**3**) with a variety of aldehydes under solvent-free conditions. Moreover, PEGMA-g-TEGBDIM was easily reused and it maintained its high catalytic activity and stability even after seven reaction-cycles. This protocol perfectly obeys the features of green chemistry, including having no waste regarding side-products, being solvent-free, and having free from column chromatographic purification.

## 1. Introduction

Heterocyclic backbone structures are playing an important key role in most science areas, such as pharmaceuticals, material science, and catalysis.[1] Most of the novel drugs discovered possess a significant amount of new scientific insight with heterocyclic skeletons in medicinal chemistry that occur at the interface of chemistry and biology.[2,3] Therefore, for decades, new advances in diverse research areas of heterocyclic chemistry with noble skeletons and different ring sizes have occurred for the development of new organic methodologies.[4–6] In particular, for the simultaneous or sequential formation of two or more bonds with a high degree of selectivity and great structural complexity, the most suitable synthetic tools are solvent-free multicomponent reactions.[7–10]

Benzo[4,5]imidazo[1,2-*a*]pyrimidine derivatives are privilege-type heterocycles in drug discovery and frequently present as part of biological interactions with a broad spectrum of biological properties.[11,12] This family of heterocycles has received significant attention in advanced materials, pharmaceuticals, natural products, agrochemicals, and ligands.[13–16] Hence, several authors reported this family of heterocycles that can act as a pharmacophore in various types of pharmaceuticals or drug candidates, such as anti-inflammation agents, anticancer agents, anti-metabolic agents, DNA-topoisomerase I inhibitors, antineoplastic agents, antimalarial agents, antitubercular agents, benzodiazepine receptor agonists, calcium channel blockers, kinesin inhibitor, and Parkinson's drug candidates.[17–20] Therefore, various method have been developed for the preparation of benzo[4,5]imidazo[1,2-*a*]pyrimidine.[21–24] However, some of these methods have suffered with one or other limitation such as harsh reaction conditions, prolong reaction time, unsatisfactory yield, and the use of non-recyclable and/or toxic catalysts. In this regard, investigations are still going for a better method for the synthesis of benzo[4,5]imidazo[1,2-*a*]pyrimidine.

The main theme of contemporary green chemistry is guided by lining the greener and cost-efficient processes with environmentally benign catalytic systems.[25–27] In this context, ionic liquids (ILs) are innovative and environmentally-friendly reaction media. ILs have attracted considerable interest in catalysis chemistry (as solvents, catalysts, or catalyst carriers) due to their favorable properties.[28–31] In spite of the wide use of ILs for the preparation of

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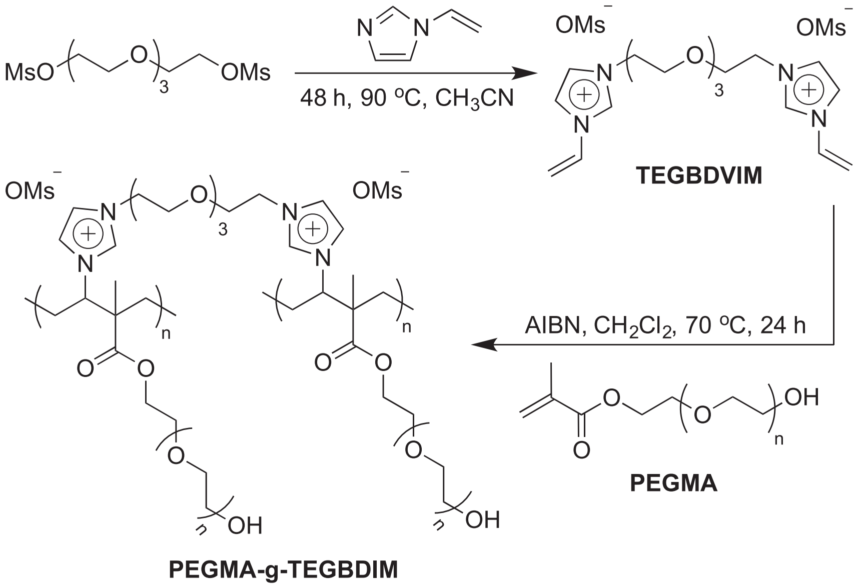

**Scheme 1.** Preparation of polyethylene glycol methacrylate-grafted tetra-ethylene glycol-bridged dicationic imidazolium-based ionic liquid (PEGMA-g-TEGBDIM).

heterocyclic scaffolds[32,33] in homogeneous catalytic processes, some limitations, such as catalyst recovery, difficulty in the separation of organic products from the ILs phase, and high cost for the use of relatively large amounts of ILs, are hindering their merits. To overcome these disadvantages, there have been several attempts on the immobilization of ILs to the surface of different solid materials, such as polymers, silica, carbon nanotubes, magnetic materials, graphene nanosheets, and inorganic materials.[34–40] To unite the diverse properties of ILs and polymers, ILs have also been supported on cross-linked polymers and developed in modern chemistry.[41–45] Because of the important properties of polymers as supports for catalytic species, polymeric ionic liquids (PILs) have been widely studied and are of growing interest as they combine the unique properties of ILs. The extensive study of the effects of PILs on various organic reactions has shown that they have superior catalytic activity with a much faster reaction rate and higher yield than conventional IL reactions.[46–49]

Herein, we introduce a simple, inexpensive, highly stable and reusable polyethylene glycol methacrylate)-grafted tetra-ethylene glycol-bridged dicationic imidazolium-based IL (PEGMA-g-TEGBDIM) prepared by a cross-linked polymerization reaction of tetraethylene glycol-bridged dicationic 1-vinyl imidazole salts (TEGBDVIM) and polyethylene glycol methacrylate (PEGMA). This may be the first demonstration of the facile synthesis of PEGMA polymers with lower production cost and an uncomplicated preparation procedure by following the grafting of IL on a polymer. This combination results in PEGMA-g-TEGBDIM and has some excellent advantages, such as high thermal stability, good structural stability, high surface area, higher catalytic activity, lack of diffusion phenomena, and reusability. Alternatively, our main goal of this research is to demonstrate the environmentally benign green synthetic utility and catalytic activities of this PEGMA-g-TEGBDIM in rapid multicomponent reactions of a variety of aldehydes with 1*H*-benzo[*d*]imidazol-2-amine and (*E*)-*N*-methyl-1-(methylthio)-2-nitroethenamine to produce the corresponding aryl-benzo[4,5]imidazo[1,2-*a*]pyrimidines under solvent-free conditions.

## 2. Result and discussion

A facile and efficient method for the synthesis of PEGMA-g-TEGBDIM was successfully developed *via* reversible addition fragmentation chain transfer (RAFT) polymerization by a modified procedure (Scheme 1).[50] Treatment of tetraethylene glycol dimesylate with 1-vinylimidazole produced TEGBDVIM, and subsequent RAFT polymerization of TEGBDVIM with PEGMA in the presence of azobisisobutyronitrile (AIBN) produced PEGMA-g-TEGBDIM as a white solid. The formed polymer was confirmed by FT-IR, solid state NMR, XPS, and TGA.

As shown in the FT-IR spectrum of PEGMA-g-TEGBDIM and TEGBDIM (Fig. 1), the preparation of the expected polymer-product was confirmed. Important conformations of the product formation were (i) the disappearance of terminal alkene (=C–H) stretching vibrations and corresponding bending vibrations of TEGBDIM at 3069.7 and 1572.1, 1549.8, 1192.1, and 1045.1 cm$^{-1}$, respectively, and (ii) the appearance of a strong carbonyl group absorption peak at 1727.7 cm$^{-1}$. In addition, the appearance of the enhancement in the intensity of two strong absorption bands at 2935.4–2867.7 and 1117.2–1105.3 cm$^{-1}$ of corresponding aliphatic –C–H and ether (C–O–C) groups, respectively, indicated the successful polymerization of PEGMA with TEGBDVIM. Along with these, imidazole ring C=N stretching vibrations were also observed in both spectra in

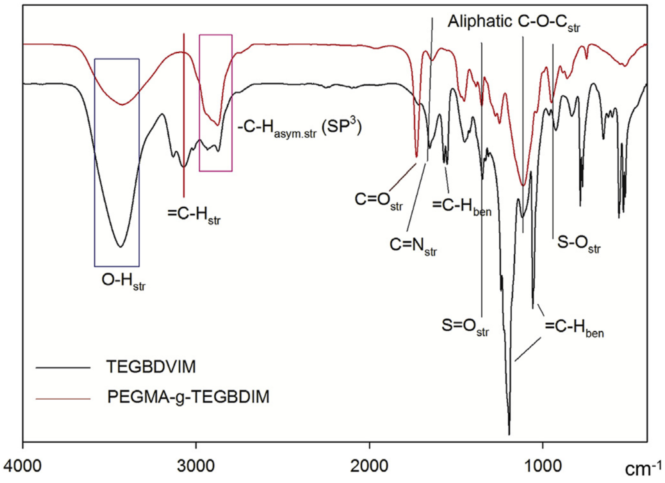

**Fig. 1.** FT-IR spectra of PEGMA-g-TEGBDIM and TEGBDVIM.