Rapid recycling of waste plastics via simultaneous dual carbonyl activation of ethanediylester groups in PET

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ABSTRACT

Efficient recycling of polyethylene terephthalate (PET) plastics is crucial for mitigating environmental pollution and regenerating fossil resources. However, current PET recycling technologies predominantly rely on substantial quantities of unrecyclable chemical reagents, noble metal catalysts, or stringent conditions. Here we report an effective method of depolymerizing PET to terephthalic acid (TPA) and ethylene glycol (EG) by hydrolysis in green ionic liquid cholinium phosphate ($[Ch]_3[PO_4]$) under mild conditions. Traditional hydrolysis methods only activate one oxygen atom in PET's ethanediylester group, whereas our approach uses both ends of one choline cation to activate two oxygen atoms of the ethanediylester group simultaneously. This synchronized dual activation significantly enhances the electrophilicity of carbonyl carbons, thus accelerating the hydrolysis process. Theoretical calculation and experimental results show the PET conversion of simultaneous two carbonyl oxygen atoms activation was much higher than that of one carbonyl oxygen atom activation. Concurrently, phosphate anions increase the nucleophilicity of water, making it easier to attack the carbonyl groups, thus facilitating the efficient depolymerization of PET. Meanwhile, $[Ch]_3[PO_4]$ is recyclable, low in corrosiveness, and harmless, making it highly promising for industrial applications. This work proposes a groundbreaking mechanistic paradigm to effectively depolymerize PET by simultaneously activating the ethanediylester group between its two benzene rings.

Keywords: Polyethylene terephthalate; Dual carbonyl activation; Hydrolysis; Ionic liquid