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Bio-based poly(hydroxy urethane)s for efficient organic high-power energy storage

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PURPOSE OF THE ABSTRACT

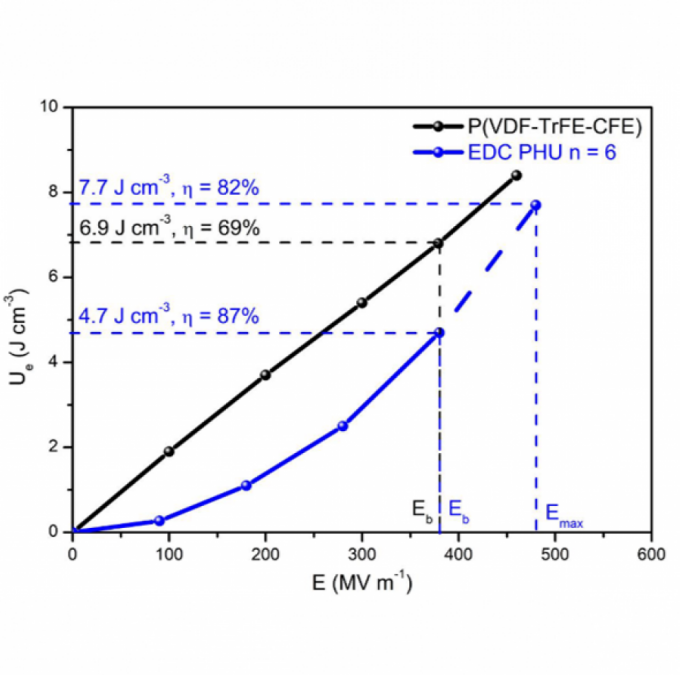
The increasing demand in energy combined with the environmentally-motivated move away from fossil fuels has led to huge investment in more sustainable methods to produce energy, such as the exploitation of wind or solar power. However, the intermittence of these energy sources, and the increasing need for nomadic energy, has made the necessity for fast, low-cost and efficient energy storage technologies all the more critical. Dielectric-based capacitors are promising candidates, due to the high-power range that they inherently afford, resulting from their fast charge and discharge cycles.

High-power dielectric capacitors require both high permittivity (?r) and breakdown field, which has made vinylidene difluoride VDF-based homo- and co-polymers the standout organic candidates. However, none of these polymers can be bio-based, which will hinder their long-term use. Most other polymers have low permittivity (?r ~ 2-4). A new class of promising amorphous polymers have recently emerged as alternatives, referred to as dipolar glass polymers [1-2]. They combine highly polar side groups such as hydroxyl or sulfonyl groups with a high-temperature glass transition (Tg), which increases their operating temperature and decreases the dielectric losses. Due to their high concentration of hydroxyl groups and highly tuneable Tg, poly(hydroxy urethane)s (PHUs) could meet these criteria, with the added benefits of being potentially bio-based.

A series of PHUs were synthesised from reacting diglycerol dicarbonate (DGDC) or butadiene dicarbonate (BDC) with bio-based diamines (H2N-R-NH2) by reactive extrusion. The position of the Tg was manipulated through the structure of the diamine. As a result, 0°C < Tg < 100°C were obtained.

PHUs with Tg below and near room temperature showed remarkably high permittivity values (?r > 30). Unfortunately, these were accompanied with high dielectric losses due to the proximity of Tg. However, when the Tg was increased to 50 °C (R = C6), high permittivity values were maintained (?r > 10) but the dielectric losses were significantly reduced (tan ? = 0.03 ? 0.04). If the breakdown strength of these polymers, which is currently being characterised, was found to be high enough, they could represent a highly promising route to environmentally-friendly organic energy-storage.

FIGURES



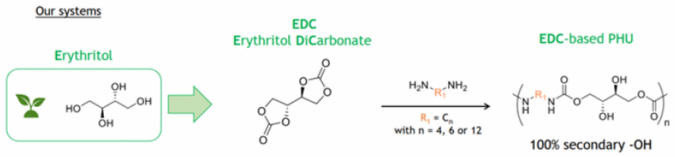


FIGURE 1

Energy storage performance

Storage performance comparable with P(VDF-TrFE-CFE) and huge discharge efficiency

FIGURE 2

NIPU synthesis

Bio-based poly(hydroxyurehane) synthesis

KEYWORDS

poly(hydroxy urethane) | dielectric energy storage | Bio-based

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