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Polyesters based on 2,5-thiophenedicarboxylic acid as new materials for Sustainable Packaging

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Abstract

For a long times polymer materials, named also plastics, coming from petroleum resources, have supplied most of the common packaging materials like paper, metal, glass, thanks to their better properties like softness, lightness, transparency, higher strength and low cost. However increased use of such materials has led to serious ecological problems related to their total non-biodegradability. Further, the problem of over use of petroleum resources focalized the attention on the development of sustainable alternatives. Actually, about 40% of polymers are employed as food packaging materials, principally petrochemical-based ones, due to their great performances. Their substitution by plastics obtained from renewable resources (food and plant wastes) can considered a valuable alternative to reduce the total carbon footprint. In this contest, furan-based polyesters are becoming even more attractive as the starting monomer, 2,5-furandicarboxylic acid (2,5-FDCA), is one of the twelve building blocks that can be obtained from renewable sources, such as sugars. A new monomer, the 2,5-thiophenedicarboxylic acid (2,5-TDCA), similar in structure and different just for the substitution of the O-atom with S-atom in the furan ring, has attracted growing attention, thanks to the fact that it is just industrially produced starting from renewable resources. In this contest a new class of polyester with different length of aliphatic chain were synthetized and fully characterized, using 2,5-TDCA and glycols containing 3 to 6 methylene groups, as monomers. Such polyesters were characterized in powder form, as obtained, as well as in the form of films, due to their possible use in packaging sector. In particular, thin films were characterized mechanically, to test their stress-strain performance, and regarding the gas barrier performances to the principal gases used in the food field, such as O_2 and CO_2. It was observed that the length of the glycol chain modulates the final performances of such polymers. In particular, the different chain mobility and amount of crystalline/amorphous phase developed in the samples, could play an important role in the final mechanical and gas barrier properties, giving rice to materials ranging from rigid to plastic and from

lower to higher gas barrier behavior. Further, in all samples investigated was evicted a further structural phase, named mesophase, characterized by a lower degree of order than the crystalline one, but similar to the amorphous phase. Such phase, whose amount is strictly related to the aliphatic chain length, was considered responsible of the peculiar mechanical and gas barrier performance of the synthetized materials. A comparison between thiofuran-based homopolymers and their furan-based homologues was carried out.

Keywords: sustainable packaging; furan-based polyesters: thiofuran-based polymers; structure-property relationship; gas barrier behavior; food packaging; renewable resources

References

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