Bio-based films prepared with by-products and wastes: environmental assessment

I. Leceta, A. Etxabide, S. Cabezudo, K. de la Caba, P. Guerrero*

Biomat Research Group, University of the Basque Country (UPV/EHU), Polytechnic School, Plaza Europa 1, 20018 Donostia-San Sebastián, Spain

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Considerable interest in bio-based films has been renewed due to their potential use in packaging industries. Polymers from biomass receive increasing interest as potential substitutes for certain conventional polymers since they are derived from renewable sources and can be biodegradable. However, the life cycle assessment of biofilms has not been widely reported in the literature. In this context, this paper discusses the environmental assessment of bio-based films based on agro-industrial by-products and marine residues, providing added value to these wastes. The materials employed to prepare the bio-based films were soy protein obtained as by-product of soy oil industry, chitosan obtained from the skeleton of crustaceans, and agar obtained from marine seaweeds. The results showed that manufacture is the most contaminant stage for chitosan and agar films, whereas the extraction of raw materials is the stage with the highest environmental burden for soy protein films. In addition, soybeans cultivation contributes to the environmental burden in land use category due to the use of glycerol, considered as by-product from biodiesel production, as plasticizer. However, the end of life stage is the least pollutant phase for bio-based films due to the fact that their biodegradable nature allows composting as the end of life scenario, providing environmental benefits. The present study allows identifying the most pollutant phases of the life cycle for biofilms from different resources, which is the first step prior to the analysis of the changes needed during the design of products and processes to minimize negative impacts in the environment.

* Corresponding author. Tel.: +34 943 017163.
E-mail address: pedromanuel.guerrero@ehu.es (P. Guerrero).

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1. Introduction

Concerns over the dwindling availability of petroleum-derived resources and landfill sites are driving interest in renewable and biodegradable polymers nowadays (Gandini and Belgacem, 2008). The durability of traditional plastics, which makes them ideal for applications such as packaging, can also lead to waste-disposal problems, since these materials are not biodegradable. Apart from the disposal, the fabrication of industrial products should also take into account raw materials from renewable resources in order to preserve fossil resources (Hopewell et al., 2009). Currently, two approaches are explored to minimize the impact of the use of non-biodegradable petroleum-derived polymers: first, the design of polymeric materials for long duration, such as biocomposites (Ashori, 2008); second, technological innovations designed for the production of polymers for short duration, such as disposable packages (Platt, 2006; Rudnik and Briassoulis, 2011), which is within the aim of this work. Although the most widely used renewable packaging materials are paper and board, which are based on cellulose, major efforts are under way to find alternative polymers (Cunha and Gandini, 2010; Mooney, 2009). Owing to the growing environmental concerns from customers and governments, many companies have explored producing bio-based products (Butler, 2009). The case of bioplastics illustrates how business models can link producers and customers through the development of new products (Iles and Martin, 2013).

Polymers obtained from renewable resources or valorization of agro-industrial and marine wastes and by-products are regarded as an attractive alternative. In the case of soy protein, it is extracted from soybeans used to obtain soy oil. During this process, soy flour is obtained as a secondary product and it can be purified to obtain soy protein concentrate (SPC) and soy protein isolate (SPI), adding value to agricultural by-products. Concerning chitosan, it is the second most abundant polysaccharide found in nature. It is obtained from chitin, a polysaccharide that is present in the skeleton of marine invertebrates, insects, some algae, and mucoraceous fungi. Despite the wide range of existing sources, chitosan is mainly manufactured from crustaceans due to the large amount of...