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Plastic pollution and the challenge of bioplastics

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The world annual production of plastic shopping bags (PBS) overcomes 5 million tons and 60 thousand PBS are used every five seconds, more than 100 billions of them are being consumed only in Europe each year. In addition, 2 millions of plastic bottles are consumed worldwide every five minutes. Currently, more than 35millions tons of wastes deriving from different plastic products are produced each year in the world and only 7% of them are recycled, the remaining waste being deposited in the landfills or dispersed in the oceans. Plastics disposal in either ground or water threatens soil fertility and marine life, whereas plastics burning releases poisonous chemicals in the air. Nowadays, people are more aware about the harmful effects of the presence in the environment of wastes derived from plastic materials. A possible solution to reduce the consumption of the traditional plastics of petrochemical origin and, consequently, plastic waste disposal, is their replacement with biodegradable materials (generally called "bioplastics"). Bioplastics seem an attractive eco-friendly alternative since they can be easily degraded by the enzymes present in different microorganisms. The main biopolymers used so far to prepare these innovative biomaterials are some aliphatic polyesters (e.g. polylactic acid and polyhydroxyalkanoates), various polypeptides (e.g. soy and whey proteins, collagen, gelatin) and numerous polysaccharides (e.g. cellulose, starch, chitin, pectins) obtained from plant or animal feedstocks. It is possible to produce bioplastics by starting from bio-based monomers (e.g. lactic acid), obtained by fermentation or conventional chemistry and polymerizing them in a second step. Further ways are both the polymer biosynthesis directly in microorganisms or in genetically modified crops (e.g. polyhydroxyalkanoates) and the utilization of natural biopolymers (e.g. polysaccharides and/or proteins) recovered from organic waste. However, different bioplastics are prepared for different applications. Cellulose is the most used biopolymer in the food industry, where edible coatings are produced to improve food quality and can be consumed together with the packaged products. Novel edible films with different morphological, mechanical and permeability properties and containing various antimicrobial and/or antioxidant additives are increasingly issued from the scientific literature in order to improve the shelf-life of different foods. Conversely, starch is currently the most used biopolymer outside food industry and thermoplastic starch, often blended with caprolactones and other biodegradable esters, constitutes today about 50% of the total bioplastics market. Packaging is the largest field of application for bioplastics covering almost 40% of the produced biodegradable articles (consumer goods, 22%; transport sector, 14%; construction and building sector, 13%). However, although global bioplastics market has been reported (Allied Market Research) to reach more than 30 billion dollars by 2020, the biodegradable materials are still considered "potential" rather than "commercial" materials. In fact, they replaced until now only 1% of the 300 million tons of the total plastics produced annually, their limits being poor mechanical and barrier properties. But, as demand is rising and more sophisticated products and applications are emerging, the market of bioplastics is rapidly changing. According to the latest data (European Bioplastics), global production capacity is predicted to grow from around 4.2 million tons in 2016 to approximately 6.1 million tons in 2021. The most important factors able to influence such a positive trend might be

i. An enhanced consumer awareness to increase the demand of bioplastics, as well as new laws facilitating the companies to produce them

ii. Improved interactions between academia, industry and government institutions and, mostly

iii. The production of new biomaterials with improved and tailored characteristics. In this respect the preparation of innovative biodegradable films reinforced by nanoparticles (e.g. TiO_2, FeO, SiO_2, mesoporous silica, carbon nanotubes) and/or by enzyme-catalyzed (peroxidase, tyrosinase, transglutaminase) crosslinks, may represent a promising approach to meet the challenge to stop plastics pollution.

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Conflict of interest

The author declares no conflict of interest.

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