BIOPLASTIC FROM AGAR: HYDROPHILIC AND THERMO-MECANICAL PROPERTIES

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RESUME

Un film de bioplastique a été préparé à partir de l'agar extrait de l'algue rouge *Gracilaria verrucosa*. Les caractéristiques hydrophiliques et thermiques de ce bioplastique ont été déterminées par une série d'expériences. L'effet des concentrations en agar et en glycérol sur les propriétés du biofilm a été discuté. Les résultats montrent que le bioplastique préparé est transparent, inodore, résistant au chauffage à une température de 100°C et possède une faible perméabilité à l'eau à une température de 25°C. Il préserve également une texture intacte durant au moins 9 mois à la température ambiante.

ABSTRACT

In this study, we prepared bioplastic from the red alga *Gracilaria verrucosa* agar. Characteristics of this bioplastic derived agar are evaluated under a set of experiments. We discussed the potential role of agar and glycerol concentration on improving the bioplastic texture, elasticity and strength. We reported here that the obtained bioplastic is transparent, odorless, resistant to heat above 100 °C and had low water permeability at 25 °C. It also preserved its intact texture and proprieties during at least 9 months at room temperature.

INTRODUCTION

Bioplastic is the term used for plastic derived from renewable resources (Machmud et al. 2013). It is an alternative to overcome petroleum-based plastic and to design more environmentally friendly products. Studies on green plastic from algae are a promising tools due to their rapid growing (Up to 20% per day) as reported by Zuraida et al. (2012) and do to their possible cultivation. Plastic derived from marine algae are categorized as hydrocolloidal materials (Machmud et al. 2013). Without mixturing with other materials such hydrocolloidal, plastics generally could not be tailored to fit a particular requirement due to their poor water resistance and mechanical properties. Glycerol is generally required for producing such hydrocolloidal plastics to overcome their brittleness. Different species of agarophytes can be found along Tunisian coast and lagoons. The use of phycocolloid such agar to produce bioplastic is a new way to value this biological substance. Goals of this study are to exploit red alga agar as potential biofilm and determine parameters influencing and enhancing its properties.

MATERIAL AND METHODS

Bioplastic preparation: Powder of commercial and algal agar (Obtained in our laboratory with the optimized extract from *Gracilaria verrucosa*) were used (Fig. 1). Preparation of bioplastic was done by modifying the agar and the glycerol concentration.

Bioplastic properties: Characteristics of *G. verrucosa* bioplastic are evaluated under a set of experiments which are the following: *Visual inspection*: Color, aspect; *Time durability*: at room temperature; *Thickness*: measured using the optical microscope (Alphaphot-2. Ys2-H)

Thermal behaviors: weight lost (%) at increasing temperatures: 25-200°C with heating rate of 25°C/30 min; *Liquid holding capacity*: according to Rota et al. (2003), *Water uptake capacity and loss of soluble matter*: were determined according to Zárate-Ramírez et al. (2014).

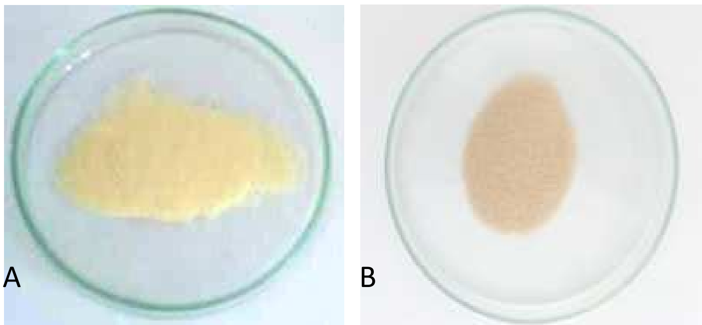

Figure 1: Commercial (A) and algal agar (B)

RESULTS

Visual observation

Bioplastic prepared from red alga and from commercial agar at different agar and glycerol concentrations was transparent, smooth and firm, however films with low agar concentration (0.25g) are more fragile than those with a higher agar concentration (Fig. 2).

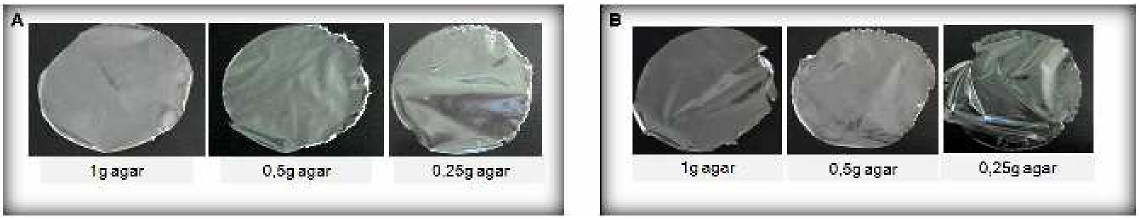

Figure 2: Commercial (A) and algal (B) bioplastic with different agar contents

Time durability: The bioplastic prepared preserved its intact texture and proprieties during at least 9 months at room temperature. *Thickness*: algal bioplastic prepared had a thickness of about 126µm.
Thermal behaviors: With increasing heat, algal bioplastic weight loss, increases proportionally with glycerol concentration. However, weight loss is inversely proportional to agar contents. The percentage of weight loss increases gradually with the increase of temperature. At 150°C weight loss exceeds 50% for almost all concentration tested of agar and glycerol. The weight loss does not damage bioplastic texture.
Liquid holding capacity: water and liquid holding capacity are proportional with commercial agar contents. For algal agar values are relatively high compared by commercial agar.
Water absorption and loss of soluble matter: at high glycerol concentration (2%) alga bioplastic is clearly less permeable to water than commercial agar. At low agar contents bioplastic demonstrated very low water permeability.

DISCUSSION

Here, agar concentration had an effect on bioplastic thermal behaviour since it is inversely proportional to bioplastic weight loss. Glycerol concentration had effect on the biofilm weight loss after heating and also on loss of soluble matters which especially increased with glycerol concentration for Commercial agar, however, value representing loss of soluble matter from algal and commercial agar are almost the same at low glycerol concentration. The role of glycerol on the bioplastic properties was previously discussed by Machmud et al. (2013) who reported that glycerol reduce considerably the opacity degree of the red alga *Eucheuma cottonii* carraghenanes bioplastic; however, bioplastic blended with latex did not show any significant modification on its physical properties. Biofilms were prepared in earlier works by Sousa et al. (2010) from the red alga *Gracilaria vermiculophylla* agar. The obtained film was transparent and optically clear showing properties similar to commercial agar. In another study by Madera-santana et al. (2011), biodegradable agar films were also produced from the red alga *Hydropuntia cornea*. *Eucheuma cottonii*, another red alga the red alga has also been used as raw material to prepare biofilms (Machmud et al. 2013). Works were conducted to prepare and characterize fresh red alga biofilms (Machmud et al. 2013).

CONCLUSION

In this study, the obtained bioplastic made from *Gracilaria verrucosa* agar is transparent, odourless, and resistant to heat above 100 °C and had low water permeability at 25 °C. Our study is amongst the first studies on agar red alga valorization as bioplastic and the first try on *Gracilaria verrucosa* agar biofilms production. These preliminary experiments demonstrated that it may be a promising alternative for natural and biodegradable plastic.

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