Biodegradability of novel graft copolymer with levan and polystyrene

Branka Lončarević[1a], Marija Lješević[1], Gordana Gojgić-Cvijović[1], Dragica Jakovljević[1], Vladimir Nikolić[2], Miroslav M. Vrvić[3], Vladimir Beškoski[3]

[1]IChTM- Department of Chemistry, Institute of Chemistry, Technology and Metallurgy , University of Belgrade, Njegoševa 12, Belgrade, Serbia;
[2]Innovation Center, Faculty of Chemistry, University of Belgrade, Studentski trg 12-16, Belgrade, Serbia;
[3]Department of Biochemistry, Faculty of Chemistry, University of Belgrade, Studentski trg 12-15, Serbia.

brankakekez@chem.bg.ac

Introduction & objectives

The significant increase in plastics production caused waste management problems which is particularly relevant for polystyrene plastic as the most dominant packaging material. Therefore, investigations of new biodegradable polymers are increasing. Graft copolymerization is important technique for physical and chemical modification of polymers [1]. The microbial levan is biocompatible, biodegradable, renewable and eco-friendly fructose based polymer. It can be produced from sucrose by wide range of microorganisms using levansucrase enzyme [2].

In the present study graft copolymer with microbial levan and polystyrene was synthetized, characterized and its biodegradable potential was investigated.

Materials & methods

Levan was isolated after fermentation of *Bacillus licheniformis* strain. After cultivation at 37 ºC, polysaccharide was obtained by ethanol precipitation after biomass separation [3]. Syntheses of copolymer were performed by the free radical reaction using potassium persulfate (PPS) as initiator [4]. Verification of the synthesis was recorded by ^{13}C NMR Bruker AVANCE III 500 spectrometer. Biodegradation potential in aerobic conditions of obtained copolymer was investigated using Micro-Oxymax respirometer (Columbus Instruments, Ohio). O_2 consumption of samples mixed with soil was measured in period of 28 days.

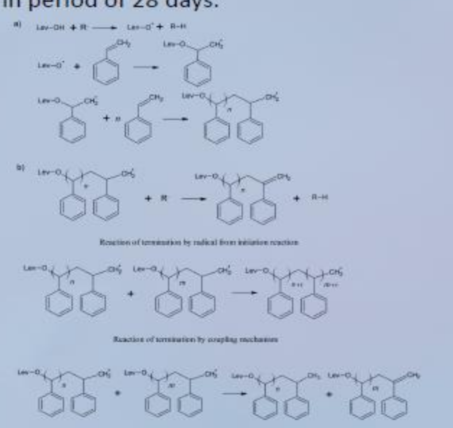

Figure 1. The reaction mechanisms in the system a) propagation and b) termination reactions.

Results & discussions

The ^{13}C NMR spectrum of copolymer showed signals that corresponded to both components (Fig 2.). The signals at 106 and 105 ppm corresponded to C-2 of β-D-fructofuranosyl units (anomeric region), and the resonances from 82 to 62 ppm were related to C-5, C-3, C-4, C-6 and C-1, respectively [3]. The resonances with chemical shifts at 120–140 ppm were attributed to the carbons of the phenyl group in grafted polystyrene, and the signals at 40–44 ppm were assigned to aliphatic structure of polystyrene [5].

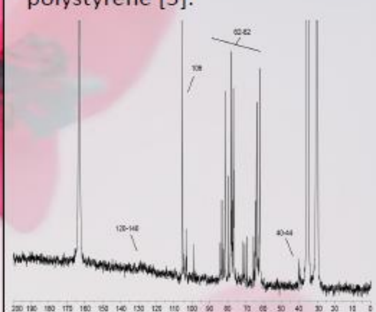

Figure 2. ^{13}C NMR of levan-polystyrene graft copolymer

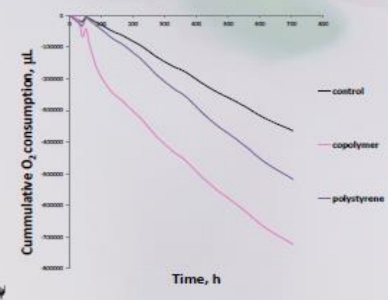

Figure 3. Cumulative consumption of O_2 of control, polystyrene and copolymer.

Figure 3 shows cumulative consumption of O_2 after respirometric measurements. Consumption of O_2 was higher in copolymer sample (705.0 L) compared to control (350.9 L) and polystyrene (499.5 L) after 673 h.

Conclusions

The formation of levan and polystyrene graft copolymer was confirmed by ^{13}C NMR analysis. Results after 28 days in aerobic biodegradation in soil shows that obtained novel copolymer has biodegradation potential, however additional tests for biodegradation are needed.

References:

[1] Sheikh *et al.* Radiat. Phys. Chem. **85** (2013) 189-192.
[2] Öner *et al.,* Biotechnol. Adv. **34** (2016) 827-844.
[3] Kekez *et al.,* Appl. Biochem. Biotechnol. **175** (2015) 3068-3083.
[4] Kekez et al. Carbohydr. Polym. **154**(2016) 20-29.
[5] Nougira et al. J. Appl. Polym. Sci. 92 (2001) 261-266. Carbohydr. Polym. **154**(2016) 20-29.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through scholarships for PhD students and funding for Project III 43004.