APPLICATION OF A FULL-FACTORIAL DESIGN TO THE CONTROL OF COLLOIDAL CHARACTERISTICS OF NON-ISOCYANATE POLYURETHANE NANOPARTICLES PREPARED BY NANOPRECIPITATION

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Nanoprecipitation is a straightforward method to obtain nano-sized polymeric particles. Nanoparticles from different polymers have already been prepared by this technique[1], but very few studies have focused on polyurethane polymers, despite their excellent mechanical properties and biocompatibility. Polyurethanes are usually synthesized by polyaddition of polyols and diisocyanates. However, for a few decades, the trend towards a greener and less toxic chemistry has encouraged research projects on non-isocyanate polyurethanes (NIPU). The greenest and most straightforward way to synthesize non-isocyanate polyurethanes is the polyaddition of bis-5(cyclic carbonate)s and diamines. The resulting polymer is called a poly(hydroxy)urethane (PHU) because of the presence of primary and secondary hydroxyl groups hanging off the main polymer chain that offers the possibility to post-functionalize the hydroxyl groups with chemical or biological functionalities[2]. We recently investigated the synthesis of PHU from hexamethylenediamine and sebacic bis-(cyclic carbonate), a bio-based cyclic carbonate and demonstrated that the nanoprecipitation technique was suitable for the preparation of PHU nanoparticles using DMSO or ethanol as the organic solvent[3]. The purpose of the present study was the improvement of the nanoprecipitation method applied to this novel polymer by the means of a full factorial design. Unlike the 'one-factor-at-a-time approach', this strategy allows determining not only the main effects of the experimental factors studied on the responses of interest but also their interaction effects. Here, we investigated the main effects and interaction effects of three independent variables − polymer concentration in the organic phase (X_1), water volume (X_2) and surfactant concentration in the aqueous phase (X_3) − on two responses – particle mean size (Y_1) and size distribution polydispersity (Y_2). In the meantime, a better understanding of the physical-chemical phenomena involved during the process is provided. Furthermore, we intended to determine the experimental conditions inducing the minimal size and PDI values. The surfactant concentration and its effect on micelles formation was particularly examined. Finally, we attempted to connect the nanosuspension stability over time with the initial characteristics of PHU nanoparticles.

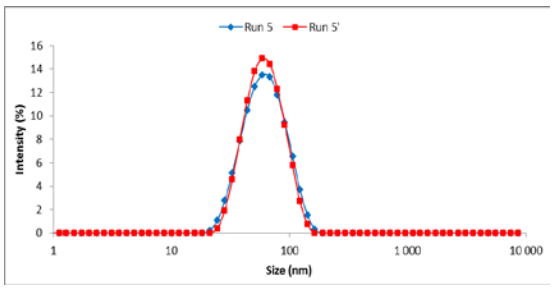

Figure 1 : Nanoparticle size distribution for sample 5 and 5'([PHU]=1g/l, V_{water} = 50 ml, [SDS]= 25.0 mmol/l)

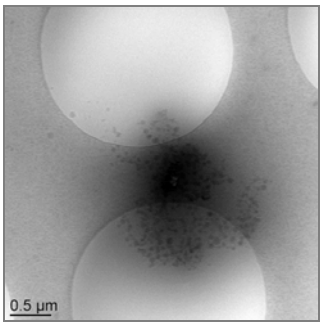

Figure 2: Cryo-TEM image of sample 8 after 57 days ([PHU]=5g/l, V_{water} = 150 ml, [SDS]= 25.0 mmol/l)

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[2] Maisonneuve, L.; Lamarzelle, O.; Rix, E.; Grau, E.; Cramail, H., Isocyanate-Free Routes to Polyurethanes and Poly(hydroxy Urethane)s. *Chem. Rev. 115* (2015) 12407-12439.
[3] Querette T., Fleury E., Sintes-Zydowicz N., Non-isocyanate Polyurethane Nanoparticles Prepared by Nanoprecipitation *Eur. Polym. J*. 114 (2019) 434-445

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