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Mussels inspired bio-polymer for H2 production at room temperature

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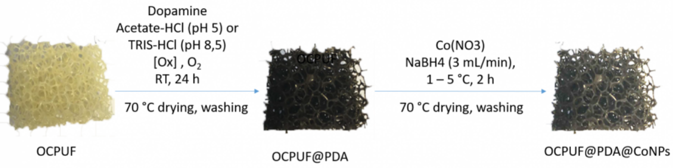
PURPOSE OF THE ABSTRACT

Open cells foams are well known as interesting structured catalytic support to improve process efficiency. Based on a previous work [1], we developed a simple, non-toxic and low consuming energy method to prepare a new catalytic polyurethane foam (OCPUF) for H2 production from NaBH4 decomposition at room temperature. The strategy consists in using polydopamine (PDA), a mussel inspired biopolymer as adhesive coat [2] for the fixation of active particles on OCPUF. PDA-coated OCPUF (OCPUF@PDA) is obtained by immersing OCPUF in a buffered solution of dopamine in presence of an oxidant at room temperature (Figure 1). The oxidative polymerisation of dopamine occurs on the foam's surface giving a PDA adhesive film. [3] Cobalt nanoparticles (CoNPs) are deposited on OCPUF@PDA by in situ reduction of a solution of cobalt nitrate on the foam's surface in presence of NaBH4 at low temperature.[4] The PDA and Co content are measured by weighing the foams. The foams were characterized by SEM micrographs combined to energy dispersive X-ray spectroscopy (EDX). We tested the foams for the catalytic hydrolysis of NaBH4 from a stabilised strong alkaline solution [5], at room temperature, in a batch reactor for the production of H2 from a non-fossil source. [6]
The dopamine can be polymerized in presence of NaIO4, CuSO4 in an acetate buffer at pH 5 or O2 dissolved in a TRIS buffer at pH 8.5. We observed that according to the nature of the oxidant, the texture of the PDA film changes. PDA is deposited as agglomerates with only O2 while it organises as micro-plaques in presence of a chemical oxidant. For the same incubation time, the PDA content is the highest using NaIO4 with 10 ? 16 wt. %. Spherical CoNPs was successfully grafted to OCPUF@PDA. The PDA film alone is active for the hydrolysis of NaBH4 due to its redox properties (Figure 2). Once doped by CoNPs, the activity is the highest as expected. However, the activity drops quickly due to PDA and cobalt leaching in strong alkaline conditions. Inspired from a method published by Kim and co-workers, [7] we proceed the Fe (+III) complexation of PDA film by dipping the foam in a FeCl3 solution at room temperature, before CoNPs grafting. The resulting foams is more resistant in harsh alkaline conditions. By this new method, we expect the foams to keep the same activity with enhanced recyclability.

FIGURES



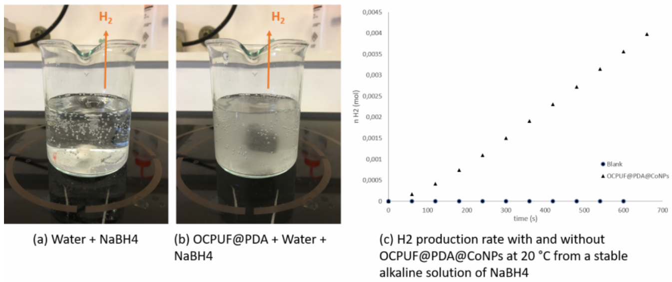


FIGURE 1

Figure 1

Polyurethane Open Cells Foam (OCPUF) coating method with polydopamine (PDA) and functionalization byin situ reduction of cobalt nanoparticles (CoNPs)

FIGURE 2

Figure 2

H2 production at room temperature (a) without foam, (b) in presence of PDA coated polyurethane foam (OCPUF@PDA) and (c) H2 production rate with and without Co doped OCPUF@PDA from a stable NaBH4 solution

KEYWORDS

Structured Catalytic Support | Polyurethane Open Cell Foam | Polydopamine | H2 production

BIBLIOGRAPHY

[1] Pardieu, E.; Chau, N. T. T.; Dintzer, T.; Romero, T.; Favier, D.; Roland, T.; Edouard, D.; Jierry, L.; Ritleng, V., Chem. Commun., 2016, 52 (25), 4691–4693.

[2] Lee, H.; Dellatore, S. M.; Miller, W. M.; Messersmith, P. B., Science 2007, 318 (5849), 426–430.

[3] Edouard, D.; Ritleng, V.; Jierry, L.; Chau Dalencon, N. T. T., WO2016/012689A2, 2016.

[4] Delgado, J. A.; Claver, C.; Castillón, S.; Curulla-Ferré, D.; Ordomsky, V. V.; Godard, C., Appl. Catal. Gen. 2016, 513, 39–46.

[5] Davis, R. E.; Bromels, E.; Kibby, C. L., J. Am. Chem. Soc. 1962, 84 (6), 885–892.

[6] Jeong, S. U.; Kim, R. K.; Cho, E. A.; Kim, H.-J.; Nam, S.-W.; Oh, I.-H.; Hong, S.-A.; Kim, S. H. A, J. Power Sources 2005, 144 (1), 129–134.

[7] Kim, S.; Gim, T.; Kang, S. M., Prog. Org. Coat. 2014, 77 (8), 1336–1339.