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TiO2 nanoparticles supported on polydopamine-coated open cell foams of polyurethane as an efficient solution for air water and water remediation

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PURPOSE OF THE ABSTRACT

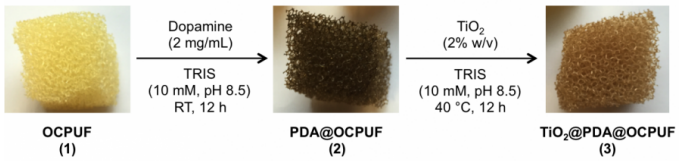
Continuous processes based on Structured Catalytic Supports (SCS) are widely used in industry. Indeed this type of support allows an important surface over volume ratio, a small pressure loss, efficient mass transfers, an intimate mixing of the reagents, and an easy separation of the catalyst from the products [1]. Among the variety of SCSs, open cell foams are prime candidates, which fulfill all these features. Of ceramic or metallic constitution, these host architectures are ideal supports for metallic particles. Their preparation however requires several steps, and the physisorption of metallic particles a thermic treatment at high temperature. This expensive and energy consuming way of preparation represents an important drawback for their development, especially when taking into account the current economic and ecological constraints. Moreover these foams are heavy and difficult to handle, rigid and fragile, and present many closed cells that render the reproducibility of the reactions unpredictable.

In this context, we have developed an alternative based on the use of polyurethane open cell foams (PUF). These inexpensive foams present the same structural and transport properties than ceramic or metallic foams, with the advantage of being easily engineered because of their lightweight and high mechanical flexibility. Inspired by a biomimetic approach based on the mussels' adhesion principle [2], we have shown that the whole surface of this polymeric structured material can be efficiently coated with an adhesive layer and further functionalized with either inorganic particles or molecular compounds [3,4]. The process relies on catechol chemistry and consists in coating a PUF with a layer of polydopamine (PDA) by simple immersion in a buffered aqueous solution of dopamine (Figure 1).

Thanks to the adherence properties of the catechol units [2], metallic or metal oxide (nano)particles can be easily grafted all over the surface of the foam by simple dip-coating [3a]. In particular, we will present that by using TiO2 nanoparticles, we have designed a flexible structured-supported photocatalyst, PUF@PDA@TiO2, that can be used to degrade a variety of air and water pollutants under batch [4a] or flow conditions [5]. Under batch conditions, the photo-degradation of a dye such as acid orange 7 can be repeated at least 5 times with the same foam with no difference in the kinetics of degradation. In addition, mechanical aging of the structured catalyst has no effect on the kinetic of the catalysis, showing the robustness of the grafting [4a]. Furthermore, thanks to the easiness of engineering of our flexible support and to its large pores that easily let light and fluids go through, PUF@PDA@TiO2 rolls have been used in a pilot flow reactor equipped with a UVc lamp under continuous conditions for the efficient degradation of formic acid in water and of acetaldehyde, acetone, n-heptane and

toluene in air (Figure 2) [5].

FIGURES



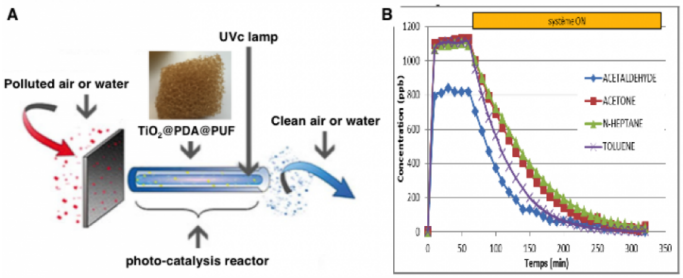


FIGURE 1

Figure 1

Polyurethane open cell foam (PUF) coating with polydopamine (PDA) and functionalization with TiO2 nanoparticles

FIGURE 2

Figure 2

A. Schematic representation of the pilot flow UV reactor. B. Photodegradation of volatile organic compounds in air (AFNOR XP B44-013 test).

KEYWORDS

Structured Catalytic Support | Polyurethane Open Cell Foam | Polydopamine | Photocatalysis

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