Photocatalytically-regenerable hyper-crosslinked microporous adsorbent

Pierluigi Lasala,[1] Khalid Tahla,[1] Antonio Maglione,[2] Antonia Cerbone,[2,3] Serena Catullo, [1] Gaia Raffaele, [1] Ombretta Giancaspro,[1] Antonella Milella,[1] Ilaria De Pasquale,[4] Rachele Castaldo,[2] Gennaro Gentile,[2] Maria Lucia Curri, [1,.4,5] Elisabetta Fanizza[*,1,.4,5]

[1]University of Bari A. Moro, Department of Chemistry, Via Orabona 4, 70126 Bari, Italy
[2] CNR- Institute of Polymers, Composites and Biomaterials (IPCB), Via Campi Flegrei 34, 80078 Pozzuoli (NA), Italy
[3] University of Naples, Department of Chemical Science, Strada Comunale Cinthia, 26, 80126, Naples, Italy
[4] CNR-Institute for chemical and physical processes (IPCF), Via Orabona 4, 70126 Bari, Italy
[5] National Interuniversity Consortium of Materials Science and Technology, INSTM, Bari Research Unit, 70126, Bari, Italy

** elisabetta.fanizza@uniba.it*

Significance and Relevance

This work aims to face the critical concern regarding water contamination by developing new adsorbents with high adsorption efficiency and easy solar-light activated photocatalytic regeneration for repeated use, through environmental friendly and cost-effective processes, targeting sustainable contaminants removal from wastewater. Adjoining to the adsorption function the solar light induced photocatalytic activity, afforded by decorating the hyper-crosslinked microporous adsorbent with purposely engineered metal oxide NPs, will provide a sustainable solar light-driven in situ regeneration.

Preferred and 2nd choice for the topic: Photocatalysis and photoelectrocatalytic approaches, solar energy utilization (Preferred); Water treatment (2nd choice)
Preferred presentation: (Oral only)

Introduction and Motivations

Adsorption, recently greatly stimulated by availability of high specific surface area materials, has grabbed the attention of scientists as a versatile, cost-effective option for relatively effortless large-scale water treatment. However, adsorbent disposing may have an adverse environmental impact that should be mitigated through regeneration and reuse processes, usually employing high-cost procedures. The validation of an adsorbent cannot be limited to prove the efficiency of the adsorption process but it must also address its lifetimes, related to the level of its reusability, the cost of regeneration treatments required to reactivate its adsorption capacity, and their environmental effects. This works aims at addressing this issue by proposing a new concept of smart adsorbents where enhanced adsorption is combined to in situ regeneration by solar-activated heterogeneous photocatalysis for an energy-efficient removal of contaminants. Metal oxide nanoparticles, synthesized by colloidal approaches, and purposely engineered to show absorption in the visible range of the electromagnetic spectrum, have been tested as photocatalysts and purposely combined to a biobased hyper-crosslinked microporous adsorbent.

Results and Discussion

Solution-phase approaches under mild reaction conditions have been exploited towards the design and fabrication of metal oxide nanoparticles (TiO_2, CeO_2) with and without dopants, engineering size and surface defects for tuneable physical and chemical properties towards excellent solar-light activated photocatalytic properties. Colloidal chemistry simple methodologies have been developed, including in-situ synthesis of the colloidal nanoparticles in the presence of microporous adsorbent or ex-situ approach, where pre-synthesized nanoparticles have been let to adsorb on the adsorbent, to adjoin the photocatalytic properties to a purposely synthesized hyper-crosslinked microporous adsorbent (Figure 1). The nanoparticle-modified adsorbent has been evaluated paying particular attention to the adsorbent structural stability, adsorption properties, nanoparticle loading and photocatalytic performance, since all these factors may effectively impact the adsorption and regeneration technology. Different aspects involved in the combination of large specific surface area adsorbents with nanometer-sized photocatalyst have been studied. The regeneration process of the adsorbent obtained photocatalytically under sunlight can be kinetically promoted by adsorption, the broad absorption of the adsorbent can extend the light response of the photocatalyst to the visible region improves the utilization of solar energy, the aggregation of the nanoparticles can be limited thanks to their anchoring on the adsorbent. In-depth investigation by structural, morphological, chemical and optical characterization have been exploited to assess the best photocatalyst candidate, understand the photocatalytic mechanisms involved in the contaminant degradation and, hence adsorbent regeneration, and the suitable functionalization procedure selected.

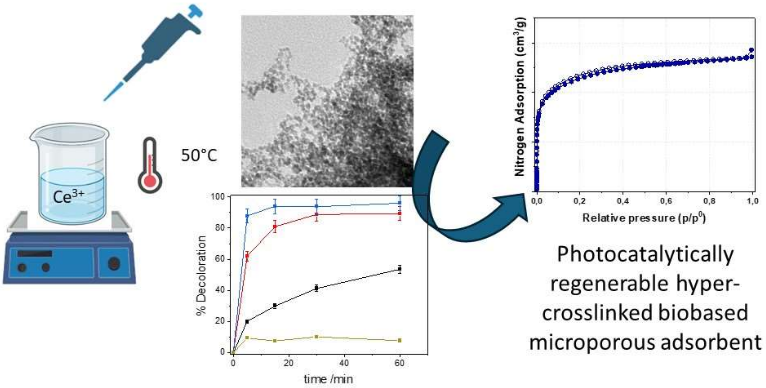

Figure 1. Schematic representation of the work objective: development of colloidal nanosized photocatalyst with suitable morphologies and photocatalytic properties, adjoined to a high specific surface area microporous adsorbent towards the fabrication of a highly efficient adsorbent regenerable by solar-light activated photocatalysis

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