

Photonic crystals as future photocatalytic materials

The use of solar radiation for energy, environment/water and chemistry purposes is highly needed for sustainable development. One of the methods is based on the application of photocatalysts (materials with ability to initiate chemical reactions under irradiation). However, the most active materials could use only a small portion of solar light (UV) for photocatalytic reactions, and all semiconductor photocatalysts suffer from the recombination of photogenerated electrons and holes, and thus low quantum yields of photocatalytic reactions are achieved.

Therefore, in this proposal the improved photocatalytic performance is proposed by enhanced light harvesting efficiency in well-ordered structure, i.e., photonic crystals (also responsible for the butterflies' colors). Photonic crystals could have different morphology, and the most typical structures are opals (usually composed of balls with almost the same sizes) and inverse opals (negative replica of opals). Here, mostly opals will be used as a template to prepare inverse opal structures, as exemplary shown in Fig. 1 (a). The properties of photonic crystals could be modulated by the change of void diameter in inverse opal, which is governed by the size of balls (forming opal). It is important to underline that little change in the void diameter could cause significant change in the resultant photocatalytic performance, as presented in Fig. 1(b). Moreover, the photoabsorption properties depend also on irradiation angle, as clearly seen in Fig. 1(c) – showing the photography of the same sample taken under different angles.

Although the research on photonic crystals is popular, and many reports have already been published (especially by physicists), there are only several papers with direct confirmation/proof that this special morphology enhances the photocatalytic activity. Additionally, multi-component photocatalysts, composed of two photonic crystals (made of different chemical compounds) have not been investigated yet. It is expected that such materials might exhibit excellent redox properties, and thus enhanced photocatalytic activity for various reactions, such as decomposition of organic compounds, artificial photosynthesis and water splitting. Moreover, other applications of obtained structures will also be investigated (in collaboration), such as for microbiology, medicine and batteries.

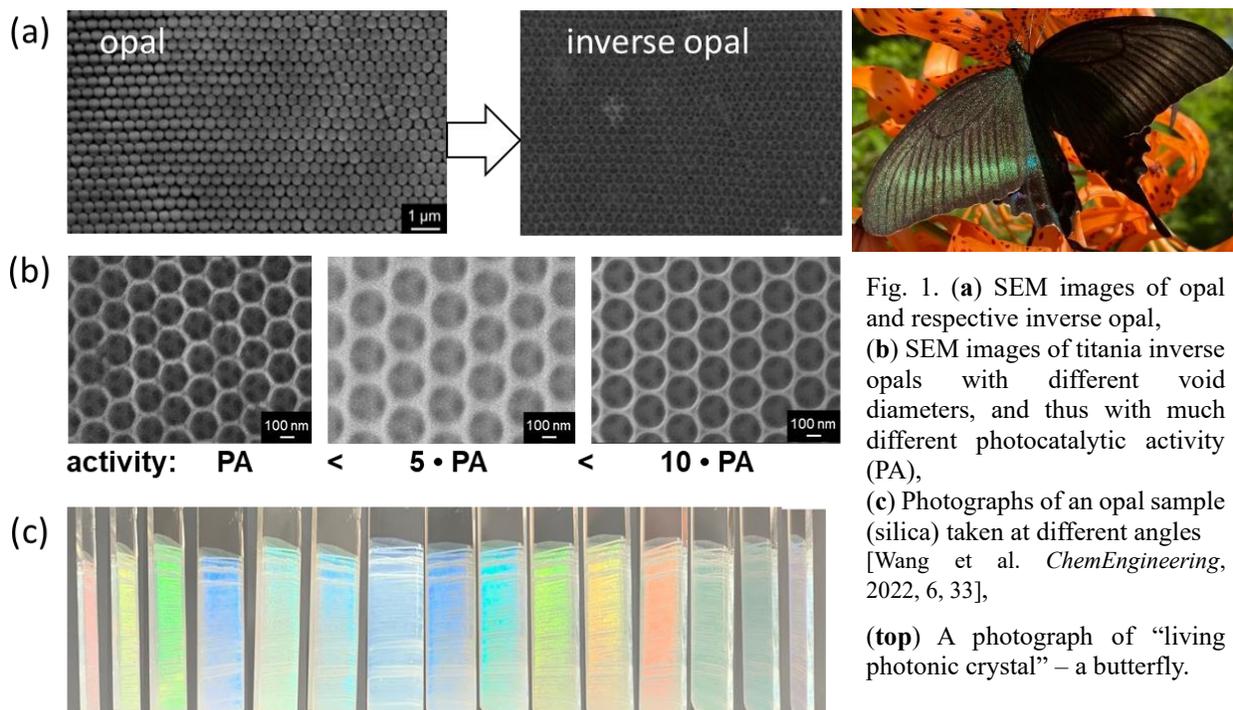


Fig. 1. (a) SEM images of opal and respective inverse opal, (b) SEM images of titania inverse opals with different void diameters, and thus with much different photocatalytic activity (PA), (c) Photographs of an opal sample (silica) taken at different angles [Wang et al. *ChemEngineering*, 2022, 6, 33],

(top) A photograph of "living photonic crystal" – a butterfly.