Photocatalytic Degradation and Defluorination of Per- and poly-fluoroalkyl substance (PFAS) using Biosynthesized TiO_2 Nanoparticles under UV-visible Light

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INTRODUCTION

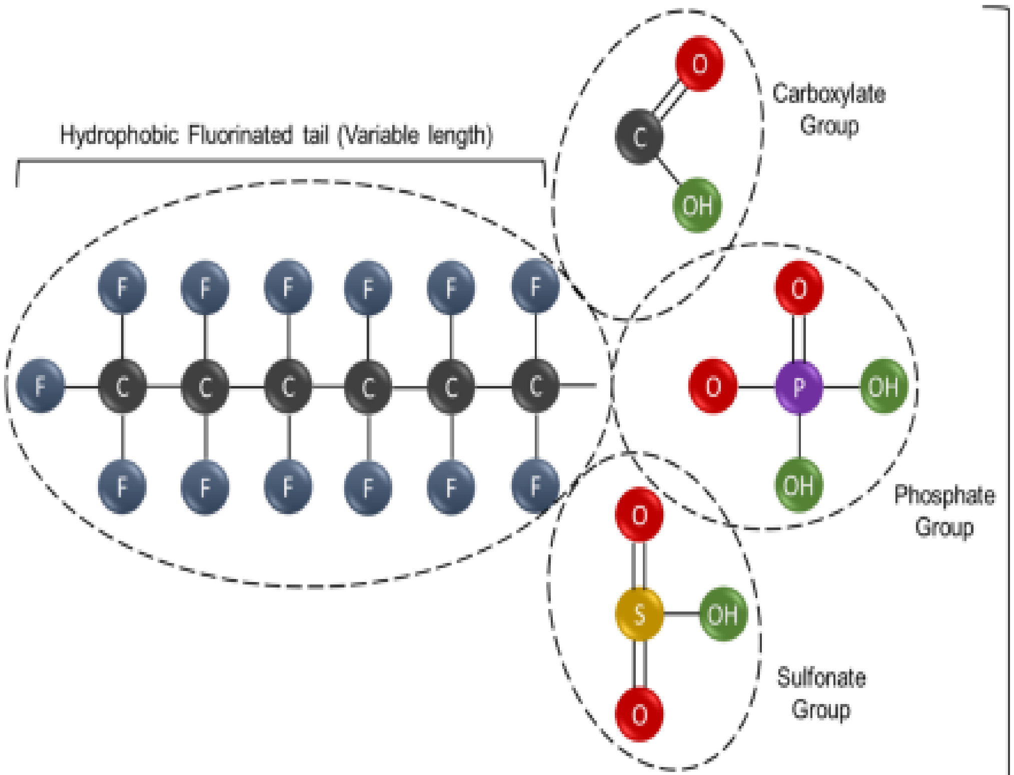
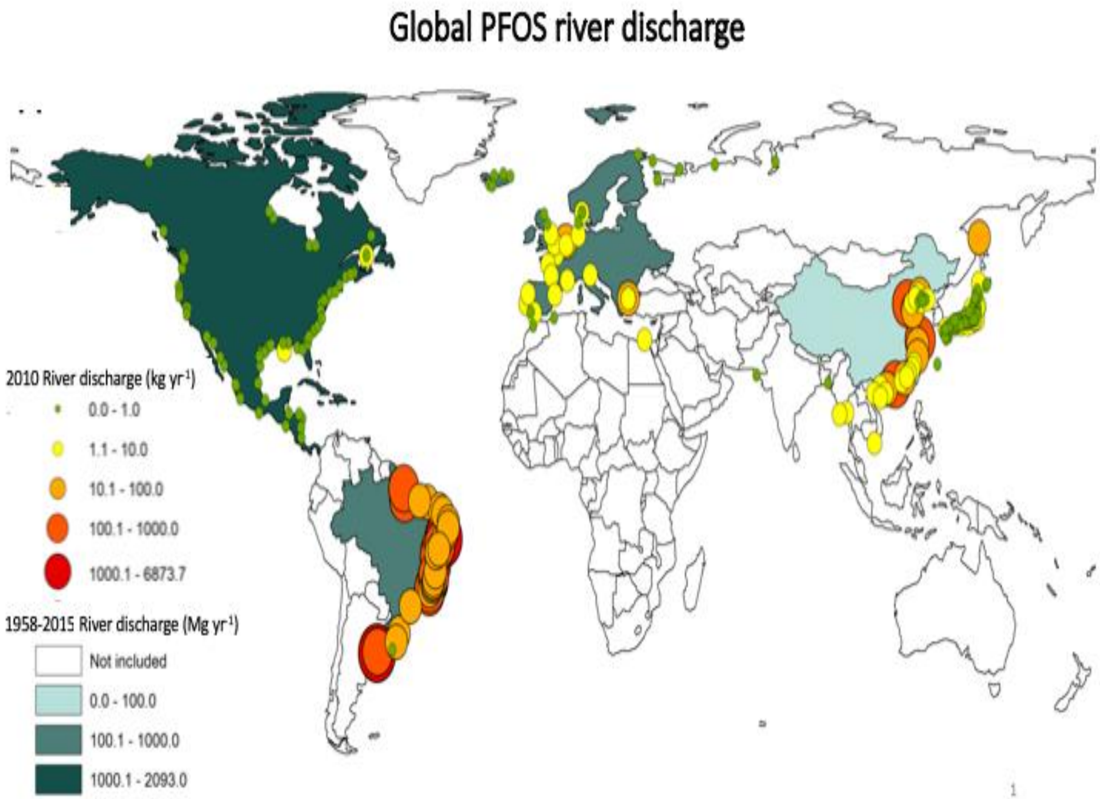


Figure 1. Overview of the general structure of perfluorinated substances (PFAS)

Figure 2. Sources of PFAS environmental distribution



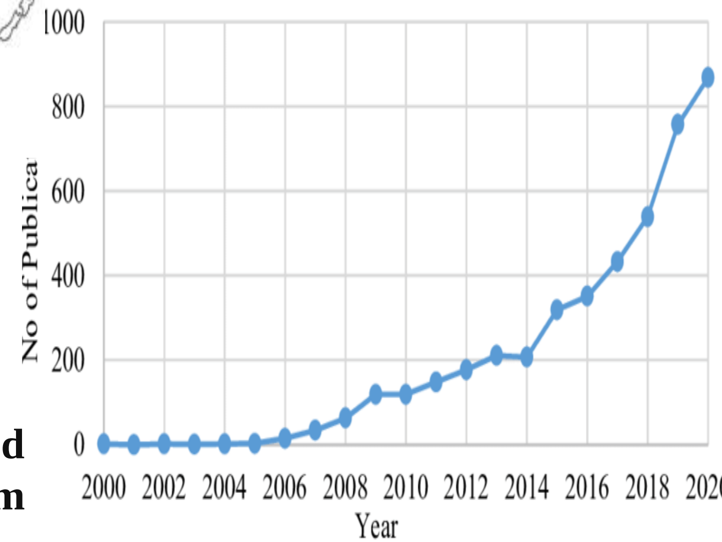


Figure 3: Total number of documents published on PFAS from 2000 to 2020 (data extracted from Scopus; October 2020).

Some previous studies on PFAS removal

Verma et al. [3] conducted research to explore the effectiveness of UV-vis/$Zn_xCu_{1-x}Fe_2O_4$/oxalic acid in the breakdown of perfluorooctanoic acid (PFOA) in water. The reactive species generated from $Zn_xCu_{1-x}Fe_2O_4$ photodegraded PFOA as a result of oxidation dissociation and defluorination.

The adsorption and solid-phase photodegradation of perfluorooctane sulphonate (PFOS) was investigated by Zhu et al. [4] using gallium-doped carbon-modified titanate nanotubes (Ga/TNTs@AC).

As a consequence of this, the TiO_2 demonstrated significantly higher photocatalytic degradation efficiencies, and the photocatalysts may also enable photodegradation.

RESULLTS AND DISCUSSION

Characterization of TiO_2 nanoparticles

Fig. 4 shows XRD patterns of TiO_2 nanoparticles at different pH. It can be seen that the synthesized samples at pH 8 to 12 showed the pure anatase phase of TiO_2. The crystallite size of synthesized TiO_2 at pH 8 (14.91 nm), 12.01 nm at pH 10, and 9.15 nm at pH 12 were calculated using Debye Scherrer Equ. (1);

$$D = \frac{k\lambda}{\beta \mathrm{Cos}\theta} \qquad (1)$$

where k is the Scherrer constant (0.94), λ is the radiation wavelength (0.152 nm) of CuKα, β is the full width at half maximum, and θ is the Bragg angle of the orientation plane.

Figure 4. XRD patterns of biosynthesized TiO_2 nanoparticles at different pH values

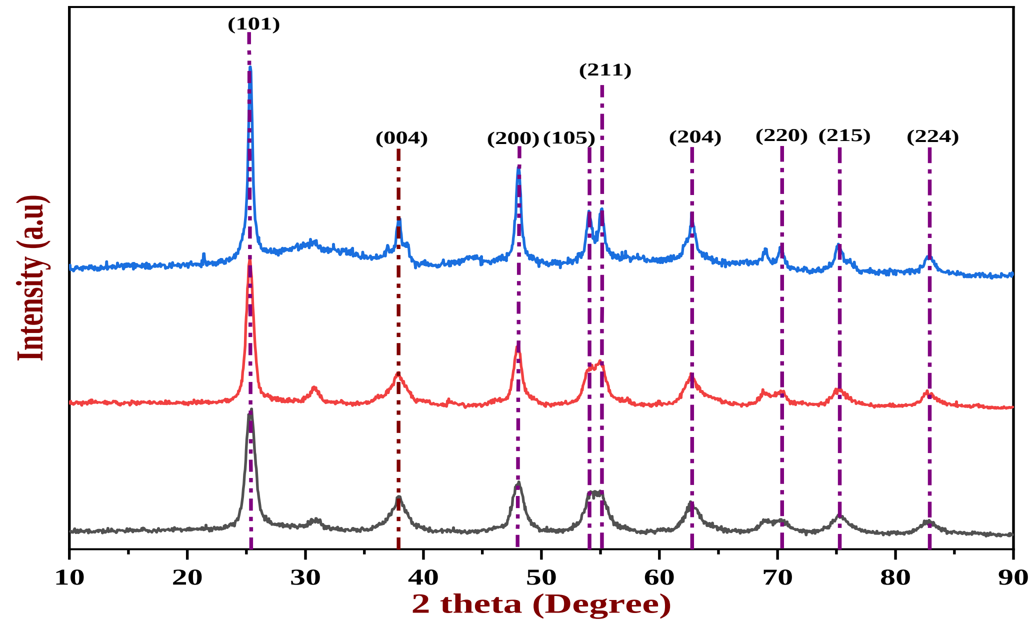


Figure 5. HRSEM image of biosynthesized TiO_2 nanoparticles at (a) pH 8 (b) pH 10 (c) 12

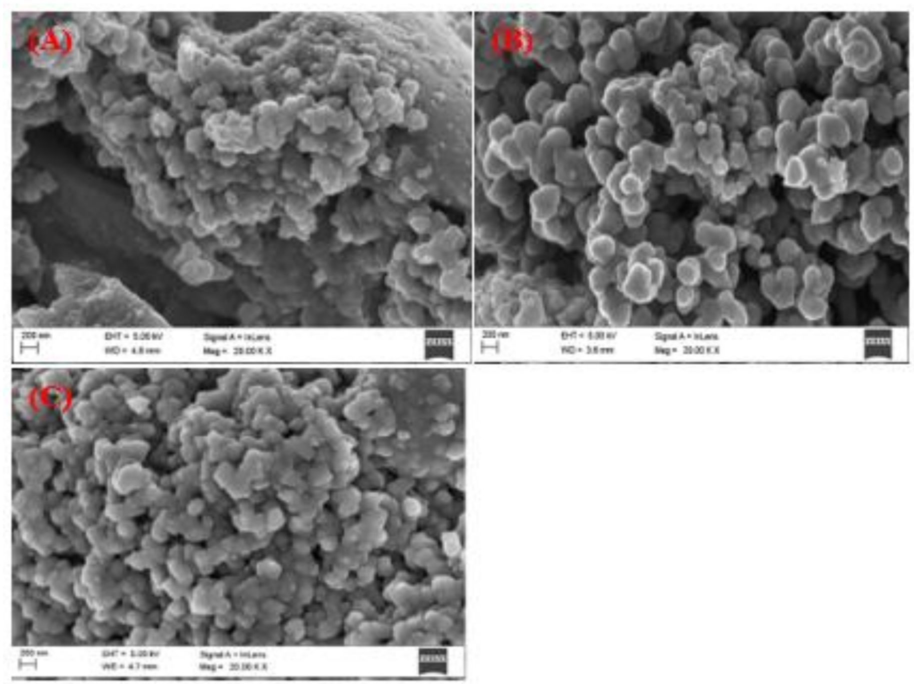
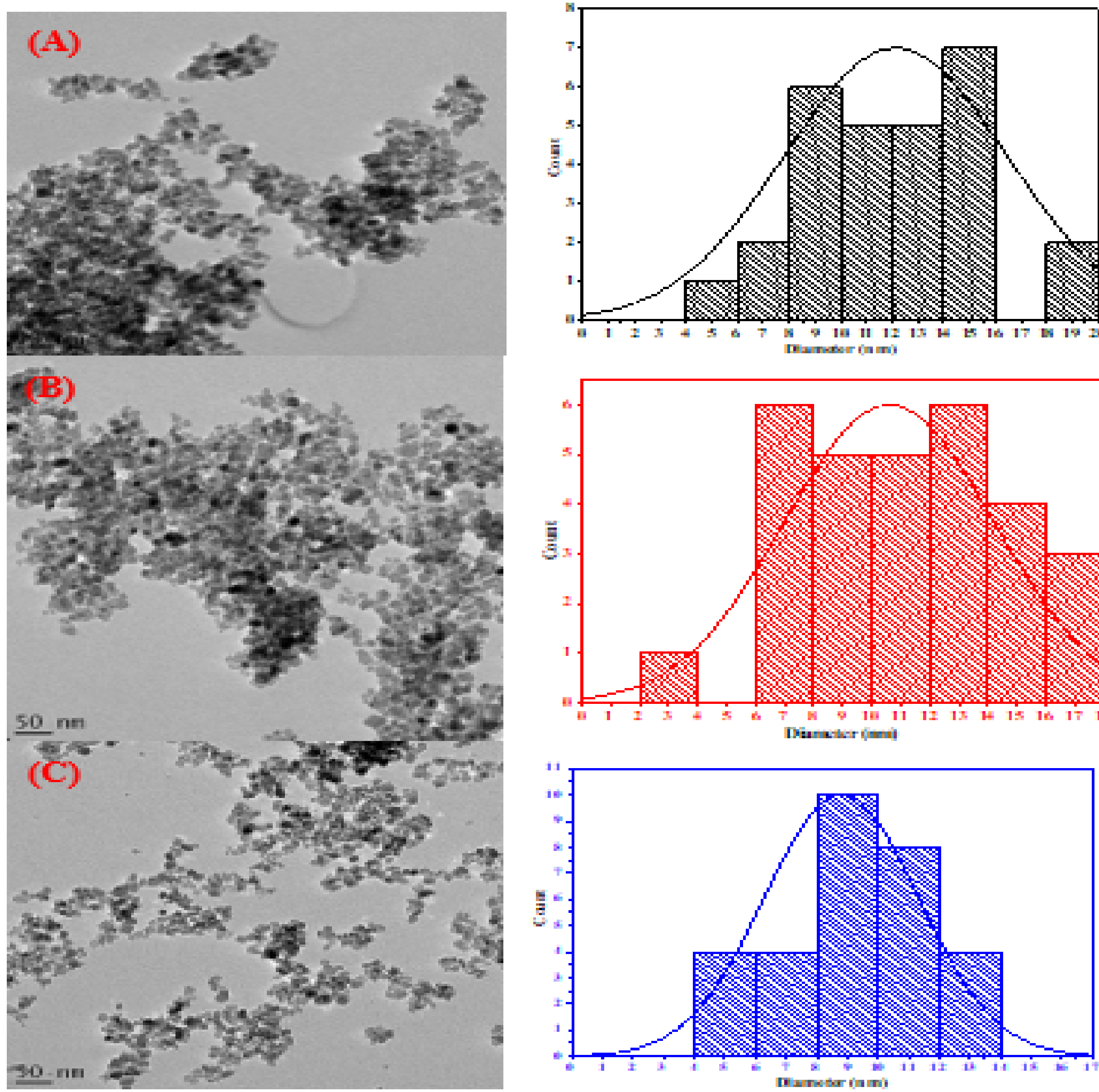


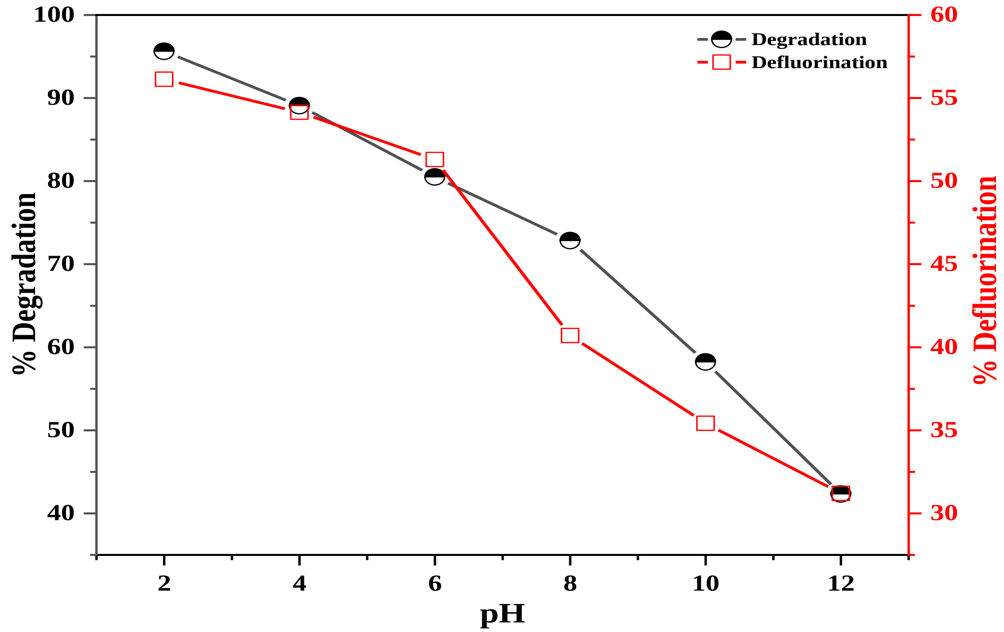
Figure 6. HRTEM image and size distribution of biosynthesized TiO_2 nanoparticles at (a) pH 8 (b) pH 10 (c) pH 12



Photodegradation and defluorination of PFOS

It was observed that as the pH increases the degradation and defluorination rates are reduced (Fig. 7). The variation in pH plays a key role in the distribution of radicals in the photocatalytic processes. The increase in the trend in PFOS with a decrease in pH solution could be attributed to the increase in the number of positive active sites on the nanoparticles at decreased pH values.

Figure 7. The effect of pH on the degradation and defluorination of PFOS



Conclusion

In summary, biosynthesized TiO_2 nanoparticles were used to demonstrate the photodegradation and defluorination of PFOS. The influence of basic pH media on the biosynthesis of the anatase phase of TiO_2 was studied. The HRSEM and HRTEM results confirmed the spherical shapes of the synthesized nanoparticles. The biosynthesized TiO_2 exhibited the highest degradation and defluorination at low pH of PFOS under UV irradiation. Thus, the findings unveil the potential of biosynthesized TiO_2 nanoparticles as a photocatalytic material for the defluorination and degradation of PFOS in water.

THANK YOU

FOR

LISTENING