Photocatalytic degradation of cytostatic/antineoplastic drug mixture by using floating chitosan and TiO_2-graphene oxide

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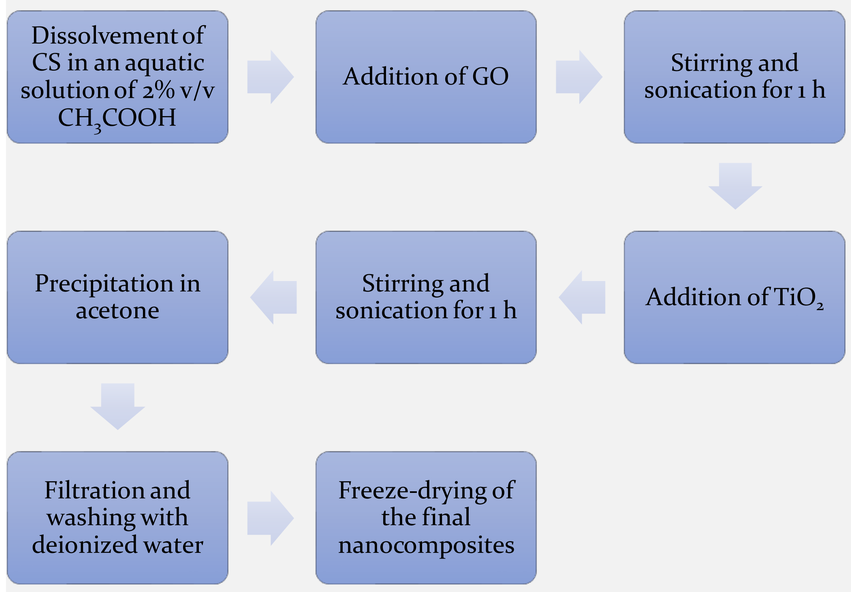
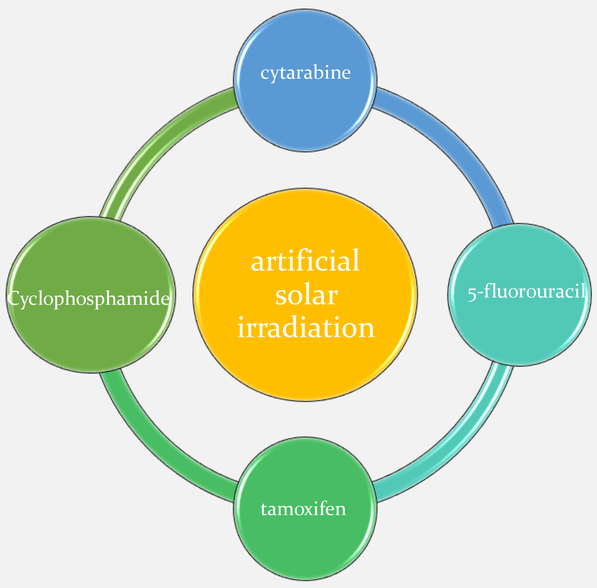
Abstract

Recently the synthesis and application of bio-based composite materials which contain polymeric and inorganic units such as TiO2 has gained much attention in the field of water/wastewater treatment, due to their better and more practical performance parameters. In the present study, floating polymer supported nanocomposites consisting of biobased chitosan (CS), graphene oxide (GO) and TiO2 nanoparticles were prepared and investigated for the removal of target cytostatic/ antineoplastic drug mixture (cyclophosphamide, 5-flourorouracil, tamoxifen, and cytarabine) in aqueous solution. The final concentrations of TiO2/GO in CS were 5, 10, 15 and 20 wt%. The synthesized photocatalysts were characterized using Fourier Transform Infrared spectroscopy (FTIR) and wide-angle X-ray diffraction (WAXD). The photocatalytic experiments were carried out under simulated solar irradiation (SSL). The effect of various factors such as variation of pH, catalyst concentration and initial substrate concentration, as well as reaction kinetics were investigated. An increase at the photocatalytic rate of cytostatic/ antineoplastic drugs was observed at higher concentrations of TiO2/GO in CS. However, at higher concentrations of TiO2/GO, the hydrophilicity of the materials increases, leading to possible decomposition. Finally, the photocatalytic treatment was investigated using liquid chromatography mass spectrometry.

Experimental

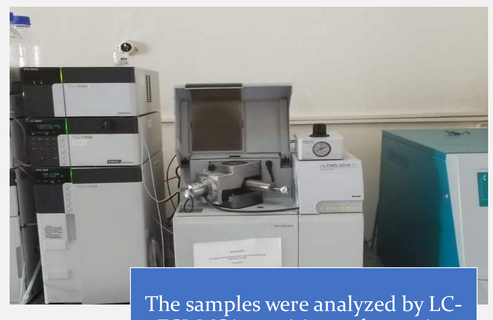
Photocatalyst synthesis





Photocatalytic degradation experiments

A solar simulator Atlas Suntest CPS+ equipped with a xenon lamp providing irradiation at 700 W m^{-2}. Experiments were performed using a Pyrex glass reactor containing 50mL of aqueous solutions, at 1 g/L catalyst, while the pH of ultrapure water was adjusted to 6.



The samples were analyzed by LC-ESI-MS in positive and negative ionization mode.

Results

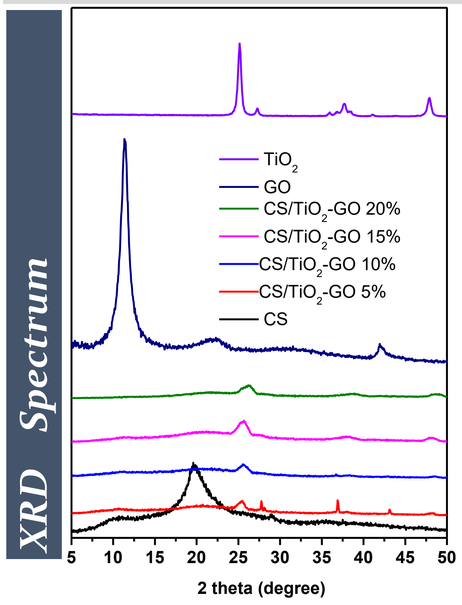


Figure 1 XRD spectrum of composites of TiO_2/GO in CS: 5, 10, 15, 20 wt%

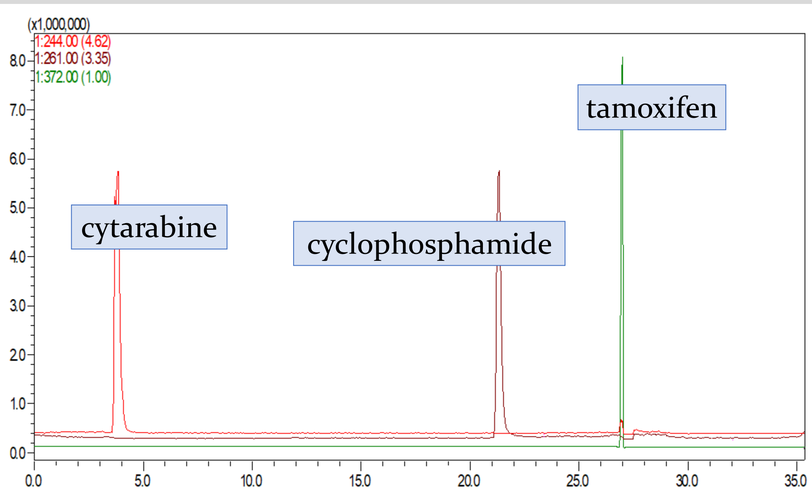


Figure 3 Chromatogram of mixture of antineoplastics in positive ionization mode

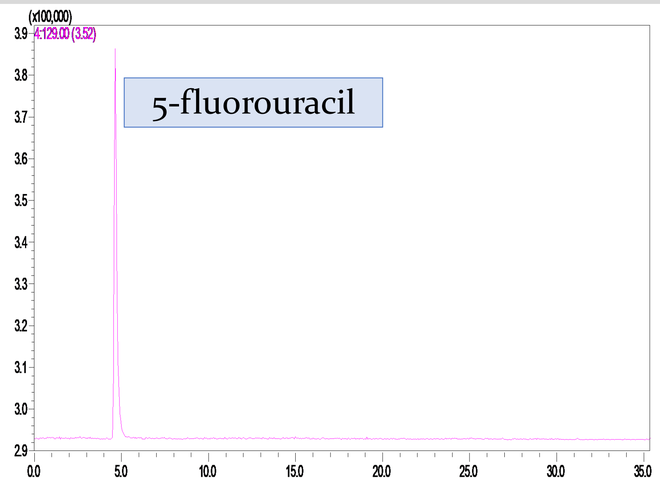


Figure 4 Chromatogram of 5-fluorouracil in negative ionization mode

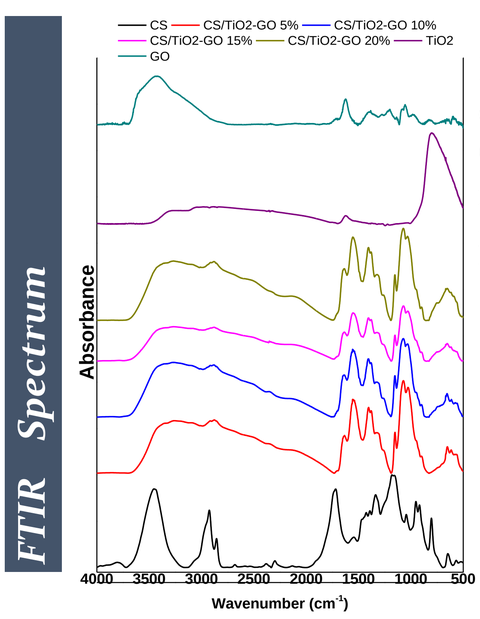


Figure 2 FTIR spectrum of composites of TiO_2/GO in CS: 5, 10, 15, 20 wt% indicating that peaks at 1658 cm^{-1} and 1595 cm^{-1} belong to NH2 groups

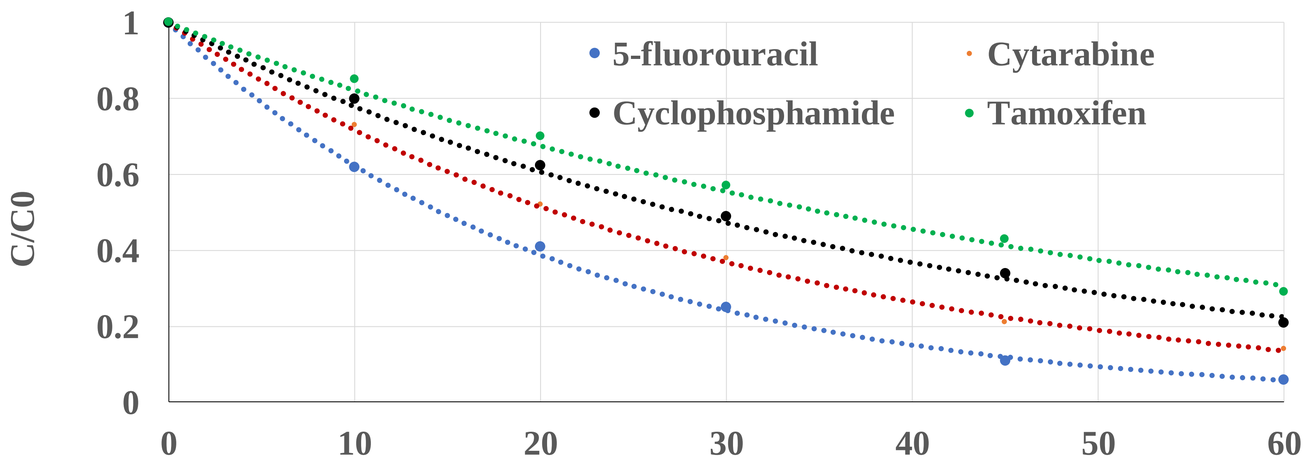


Figure 5 Photocatalytic degradation of the selected antineoplastics in the presence of 20 wt % CS/TiO_2-GO membrane (Co(drug) = 1 mg/L))

Conclusions

1. The novel biobased CS/TiO_2-GO membranes have been applied for the photocatalytic degradation of mixture of antineoplastic compounds.
2. The mixture of selected antineoplastic (1 mg/L of each) were almost eliminated in 60 min (except for tamoxifen), under simulated solar irradiation, for 1 g/L of all the studied materials.
3. An increase at the photocatalytic rate of the antineoplastic mixture was observed at higher concentrations of TiO_2/GO in CS.

Acknowledgment

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