Different Oxidation Treatments On Polystyrene (PS) Microspheres By Using An Ultraviolet/Ozone (UVO_3) System

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Abstract

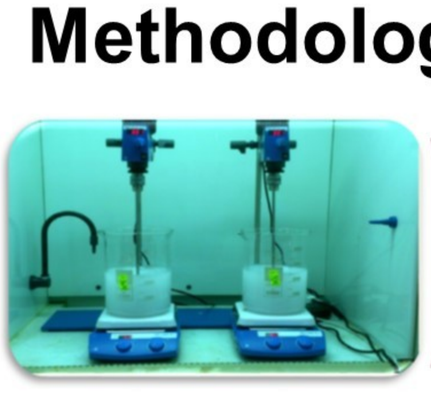
This study investigated the effects of oxidation of polystyrene (PS) microspheres by three different treatments namely oxidation by ozone aeration only, UV irradiation only or by the combination of both (UVO_3), by using a self-fabricated ultraviolet/ozone (UVO_3) system. Results expressed in carboxylic acid functional group concentrations on the surface of microspheres revealed that, treatment by UVO_3 yielded the highest concentration due to the activation of surface of PS microspheres by UV irradiation facilitated the oxidation by ozone which deposited carboxylic acid functional groups on the surface of microspheers.

Keywords: Polystyrene, microspheres, ultraviolet/ozone, oxidation

Introduction

Polystyrene (PS) is an aromatic polymer made from the monomer styrene, a liquid hydrocarbon derived from petroleum. PS is one of the most widely used plastic in cell culture most probably due to its interesting properties such as low specific weight, high chemical resistance, mechanical flexibility and biocompatible [1]. However, unmodified PS is unsuitable for cell attachment attributed to its hydrophobic surface chemistry. PS must undergo surface treatment to render it suitable for cell attachment [2]. Treatment by ultraviolet/ozone (UVO_3) has been reported as able to improve hydrophilicity of PS by introducing polar oxygen functional groups; hydroxyl, carbonyl and carboxyl on its surface [3]. Besides hydroxyl, carboxyl functional group is known to have major role in improving cell adhesion on the surface of PS. For the preparation of negative charged PS microcarrier, surface of PS microspheres requires oxidation treatment. We have fabricated a UVO_3 treatment system that allows oxidation process to be done by three different modes; oxidation by ozone aeration only, UV irradiation only or by the combination of both, UVO_3. In this work we have treated PS microspheres with all three modes, and its effects on carboxyl functional group deposition on their surfaces were investigated.

Methodology



- Preparation of PS microspheres by solvent-evaporation method

- Oxidation of PS microspheres by ultraviolet/ozone (UVO_3) system

- Measurement of deposited carboxyl functional groups on PS microspheres by toluidine blue O (TBO) assay

Results and Discussion

Fig. 1 shows the concentration of carboxyl (COOH) functional group per gram of PS microspheres after treatment. It can be observed that UVO_3 treatment has introduced the highest amount of COOH functional group on the surface of PS microspheres with 343.16nmol/g. This is followed by treatment of PS microspheres with ozone only which is 222.72nmol/g and the least concentration of COOH was achieved when PS microspheres were treated with UV only. This result is in accordance with result reported in [4] in which treatment of polystyrene by both UV and ozone have yielded higher COOH concentration on the surface of PS microspheres as compared to treatment by using ozone and UV only.

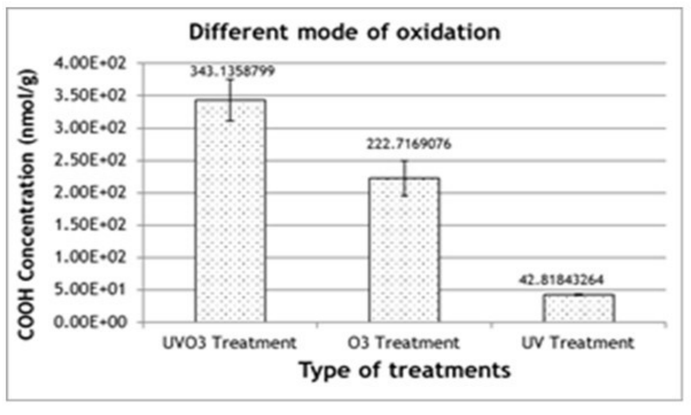


Fig.1 Effect of different treatments on COOH deposition on PS microspheres

Fig. 2 shows one of the possible reaction between polystyrene and ozone alone as reported in [5]. Presence of UV able to facilitates this reaction because according to Vicente et al. (2009) [6], UV radiation mediates the photolysis of polystyrene which leads to C–C bond homolysis (Fig. 3) and decomposes ozone into molecular oxygen and atomic oxygen [7]. These coupled reactions may explain why higher COOH concentration was achieved when polystyrene was treated with both UV and ozone when compared to treatment using ozone only.

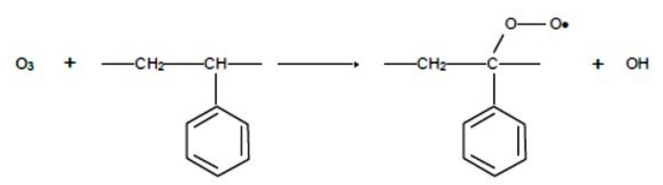


Fig.2 Reaction of polystyrene towards ozone

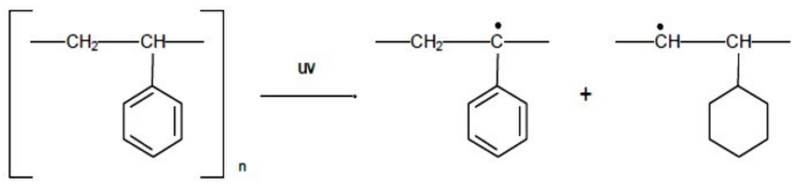


Fig.3 Photolysis of polystyrene by UV irradiation

For treatment using UV only, the low concentration of COOH introduced on the surface of PS microspheres may be contributed by 184 nm UV which is normally radiated together with 254 nm UV by UV lamps but at a very small fraction. UV radiation with wavelength of 184 nm is able to produce ozone and atomic oxygen by reacting with atmospheric oxygen.

Conclusion

As the conclusion, among three different oxidation treatment applied on PS microspheres, the combination of both UV and ozone has yielded the highest COOH concentration. Presence of UV has facilitated the oxidation reaction by scissioning of C-C and C-H bond of polystyrene and dissociation of O_3 molecule into molecular oxygen and atomic oxygen.

References

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