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Simultaneous Radiation Grafting of Acrylic Acid on Polypropylene Films: Optimization, Biodegradability and Evaluation of Ecotoxicological Impact

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Abstract
Background of the study: Polypropylene (PP) is used as a packaging material because of low cost and water resistance properties. However, it has been much criticized for its lack of degradability. Simultaneous radiation grafting is a versatile method by which acrylic acid (AAc) has been grafted on the surface of PP. From our previous work, it was found that the biodegradability of AAc grafted PP did not significantly improve beyond 34% degree of grafting. Now, there is a need to optimize the grafting condition for ~ 35% degree of grafting, and study the effects of process parameters on it. It is also important to know the ecotoxicological impact of biodegradation product of grafted PP films.
Methodology: Simultaneous radiation grafting was done with Co-60 gamma radiation. Experiments were designed based on response surface methodology (RSM) to optimize the monomer concentration (6.88-13.52 wt%), radiation dose (6.74-13.42 kGy), inhibitor concentration (0.01-0.11M) and solvent concentration (0.12-0.36 M) for the 35% degree of grafting. The grafted PP films were characterized by tensile test, fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC) and biodegradability. Ecotoxicological impact was evaluated by microbial test and plant growth (corn and tomato) test as per guidelines of Organization for Economic Co-operation and Development (OECD 208).
Results: The number of experiments reduced to 30 only for the optimization of grafting conditions for the 35% degree of grafting. The suggested optimized conditions for 35% degree of grafting were monomer concentration 12.09 wt%, radiation dose 12.40 kGy, inhibitor concentration 0.07 M and solvent concentration 0.12 M, it was also experimetlly verified in triplicate and average degree of grafting achieved was 34%, which is almost same as suggested 35% by the RSM. Grafting of AAc onto PP films was confirmed by FTIR. Tensile strength of PP18 (35% grafted) was 21.1 MPa which is suitable for packaging applications (as against 38.8 MPa of PP). The crystallinity of PP18 (26%) was lower than PP (59%) shown by DSC. The biodegradation achieved was 5.5% at 35% degree of grafting by following the guideline of American Society for Testing and Materials (ASTM D 5338-11) shown in Fig 1. Ecotoxicological test indicated that biodegradation products were non-toxic in nature.
Conclusion: Grafting conditions were optimized by RSM for 35% degree of grafting and experimentally verified. Biodegradation 5.5% was achieved with 35% grafted PP film. Eco-toxicological test confirmed that no degradation product of grafted PP has any environmental toxicity.
Keywords: Polypropylene films; Radiation grafting; Response surface methodology; Biodegradability; Ecotoxicological impact

Country/Organization invited to participate

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