Polymer Bulletin 1, 727–731 (1979)

Polymer Bulletin

Radiation Grafting of Acrylic Acid onto Polypropylene Fibres

M. H. Rao and K. N. Rao

Chemistry Division, Bhabha Atomic Research Centre, Bombay-400085, India

Introduction

Grafting is carried out on natural or synthetic textile fibres or fabrics like cotton, silk, jute, nylon, polyester, polypropylene etc. in order to modify the properties. The resulting improvement in properties are change in hydrophilic or hydrophobic nature, durability, dyeability, crease resistance, antistaticity, soil resistance and in some cases heat resistance. Not all the properties are introduced into one type of cloth nor are they required. The requirement of a particular modification and the material to be modified decides the substance to be grafted and the process of grafting. Our work on grafting of acrylic acid and methacrylic acid on polyester fibre (RAO, et al, JPS 1972; KALE, et al, JAPS 1975; RAO, et al, JAPS, in print) and acrylonitrile (LOKHANDE, et al, JAPS, in print) and acrylic acid and acrylamide on Nylon-6 fabric are published elsewhere (TRIVEDI, et al, JAPS 1975). Here we are presenting the results obtained on grafting of acrylic acid on polypropylene fibre.

Experimental

Polypropylene fibre: Type 'S' supplied by M/s. Montecatini Edison Group through the spinning of isotactic polypropylene.

Acrylic acid: Acrylic acid supplied by M/s. Aldrich Chemical Company, U.S.A. was used as such without purification.

Preparation of the samples: Polypropylene fibres were immersed in aqueous solution of acrylic acid containing a scavanger and swollen in the presence of air at 75°C for 18 hours, and then were irradiated at room temperature. For high temperature irradiation the swollen fibres were irradiated in a dewar containing ethylene glycol at the required temperature. The temperature was maintained to $\pm 2°$.

Removal of homopolymer: In case of acrylic acid graft the homopolymer was removed from the grafted

0170-0839/79/0001/0727/$01.00

fibre by repeated boiling with water. After drying under vacuum to a constant weight, the percentage graft was estimated on the basis of

$$\frac{\text{Increase in the weight of the fibre} \times 100}{\text{Weight of the original fibre}}$$

Results and Discussion

Two different scavengers, $CuSO_4$ and $FeSO_4$ have been used as scavengers of OH radicals to suppress homopolymerization and the results are given in Table I.

TABLE I

Effect of scavenger concentration on grafting

Acrylic acid 25% v/v
Irradiation 2 hours
Dose rate 2.2×10^5 rads/hr

Scavenger concentration(ML^{-1})	% Grafting $CuSO_4$	% Grafting $FeSO_4$
0.1	6.4	10.8
0.04	9.2	-
0.033	-	11.9
0.02	12.4	11.9
0.01	12.0	-
0.0033	-	11.7

From the results it is evident that $CuSO_4$ at less than 0.02M mostly scavenges the initiating species for homopolymerisation and at higher concentrations scavenges the growing grafted chains also thus reducing the percentage grafting as well. The scavenging of the grafted chains by ferrous ammonium sulfate is very much less than that of copper sulphate.

The effect of the radiation dose on PP fibres impregnated with 50% acrylic acid solution containing $CuSO_4$ as scavenger are shown in Fig.1. The results are for the cases (1) High temperature swelling and high temperature irradiation, (2) High temperature swelling and room temperature irradiation and (3) Room temperature swelling and irradiation.

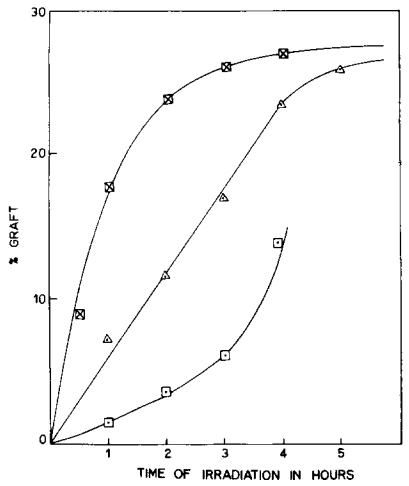

Fig.1. Grafting of acrylic acid on polypropylene fibre

⊠ High temperature irradiation
△ Swelling at high temperature. Irradiation - room temperature
⊡ Swelling and irradiation at room temperature
Acrylic acid 50% $CuSO_4$ M/50
Dose rate 2.2×10^5 rads/hr.

From the results it is seen that the maximum amount of graft is limited to 26%. The rate of grafting is higher in case (1) than case (2) although both were swollen at the same temperature. These results can only be explained as due to the increased rate of propagation of the grafted chains at the higher temperature. However, there is a limit to the amount grafted which is limited by the availability of the monomer in the swollen phase. The rate of grafting is lower in the case of the fibres swollen at room temperature and irradiated at room temperature because the availability of the monomer is lower in the swollen phase. It is presumed that the diffusion of the monomer from the solution phase to the swollen phase is hindered in the grafting process.

Besides, experiments were conducted in order to observe whether the swelling increases with increase in hydrophilicity of the grafted hydrophilic polyacrylic acid chains and if so whether the total graft increases with irradiation and also whether post irradiation grafting is possible with the system.

TABLE II

Insource and combination of insource and post polymerisation

Acrylic acid	50%
Swelling	75°C for 18 hours
Irradiation	Room temperature
Dose rate	2.2×10^5 rads/hr
Post polymerisation temp.	75°C

Irradiation time	Post-polymerisation time	Reirradiation time after post reaction	% Graft
1 hr	-	-	7.7
1 hr	2 hrs	-	13.8
1 hr	2 hrs	2 hrs	24.3
2 hrs	-	-	11.7
2 hrs	2 hrs	-	18.8
2 hrs	2 hrs	2 hrs	26.6
3 hrs	-	-	17.0

From the results it is evident that the total amount of graft obtained is only to the extent of $\sim$26%, whether the procedure shown above is followed or a simple high temperature swelling and irradiation at room temperature is adopted. These results clearly establish that after 2 hours of irradiation, the grafting is to the extent of 11.7%. The grafted polymer does not increase the swelling to any great extent when reheated at 75°C for 2 hours and then further irradiated for 2 hours as the same amount of grafting i.e. $\sim$ 26% is obtained with 4 hours of irradiation without a break. The experimental results also indicate that there is a contribution from post-irradiation grafting of about 7%. Thus, it can be seen that it is possible to get the maximum amount of graft with 3 hours of irradiation and post-treatment for 2 hours at 75°C. Post-irradiation grafting to the tune of 7% might be due to the

initiation due to the decomposition of the peroxy radicals from the backbone polymer.

The limiting grafting of acrylic acid on to polypropylene might be due to the formation of three dimensional network due to crosslinking while grafting which prevents the diffusion of the monomer from the solution phase to the swollen phase.

Acknowledgements

Thanks are due to Dr M.D. Karkhanavala, Director, Chemical Group for his interest in the work.

References

K.N. RAO, M.H. RAO, P.N. MOORTHY and A. CHARLESBY: J.Pol.Sci., 10B, 893 (1972)
P.D. KALE, H.T. LOKHANDE, K.N. RAO and M.H. RAO, J.Appl.Pol.Sci., 5, 401 (1975)
K.N. RAO, M.H. RAO, H.T. LOKHANDE, A.G. JOG and N.R. MODY, J.Appl.Pol.Sci. (In print)
H.T. LOKHANDE, N.R. MODY, K.N. RAO and M.H. RAO, J.Appl.Pol.Sci. (In print)
I.M. TRIVEDI, P.C. MEHTA, K.N. RAO and M.H. RAO, J.Appl.Pol.Sci., 5, 1 (1975)

Received July 1, 1979