

## Rapid Assessment of Weathering Stability from Exposure of Polymer Films. III. Relative Weathering Stability of ABS and Arylon, a Related Polymer Blend

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### Synopsis

Arylon, a blend of an aromatic polysulfone and a terpolymer of acrylonitrile-butadiene and  $\alpha$ -methylstyrene, weathers similarly to ABS. However its first-order rate constant for the loss of unsaturation is only  $0.39 \text{ cm}^2(\text{Wh})^{-1}$  as against  $0.80 \text{ cm}^2(\text{Wh})^{-1}$  for ABS. This slower weathering is probably caused by the decrease in light intensity penetrating Arylon compared with ABS as a result of the high degree of light scattering observed in the former.

### INTRODUCTION

Arylon is a relatively new thermoplastic which can be considered as a modified acrylonitrile-butadiene-styrene (ABS) terpolymer. In fact, as will be shown below, it is a mixture of the terpolymer acrylonitrile-butadiene- $\alpha$ -methylstyrene with a polysulfone. It is claimed, like ABS terpolymers, to combine ease of processing with good impact resistance. However, there is no information available on its weathering stability, a critical property of polymers which contain polybutadiene. It is the purpose of this report, therefore, to compare the relative stability of Arylon with a typical ABS terpolymer to outdoor exposure by the method previously described.<sup>1</sup>

### EXPERIMENTAL

The composition of Arylon, a product of Uniroyal Ltd., was determined by a combination of infrared and NMR spectroscopy. The infrared spectrum of a thin film of Arylon is shown in Figure 1. It includes absorption peaks at 4.5, 10.9, and  $3.45 \mu\text{m}$ , characteristic of ABS terpolymers<sup>2</sup> and assigned respectively to the groups  $-\text{CN}$ , *trans*-1,4 unsaturation, 1,2 unsaturation, and the substituted phenyl group. However, while VPC/mass spectrometry of the volatile products obtained by heating Arylon under vacuum at  $300^\circ\text{C}$  for about 10 min confirmed the presence of butadiene, the major product was  $\alpha$ -methylstyrene.  $\alpha$ -Methylstyrene is used

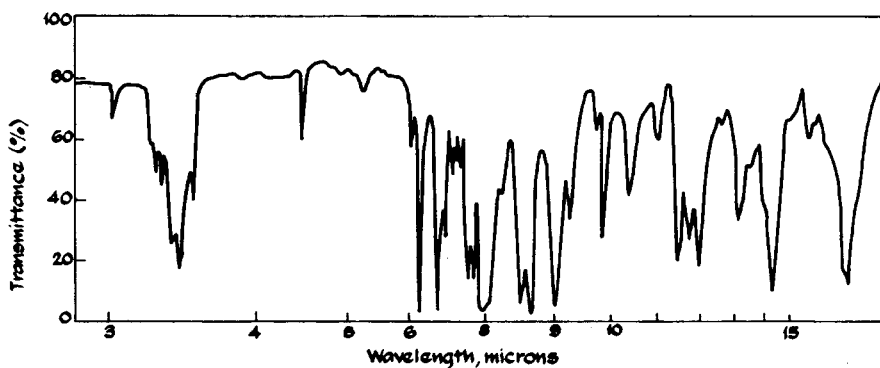
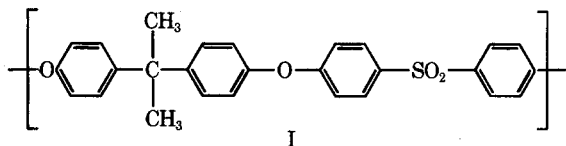


Fig. 1. Infrared transmission spectrum of Arylon film  $18 \times 10^3$  nm thick.

instead of styrene in ABS terpolymers when high processing and service temperatures are desired.

Peaks characteristic of an aromatic polysulfone can be identified in the infrared spectrum of Arylon. In particular, those at 8.0, 8.65, and 11.8  $\mu\text{m}$  can be assigned to the aromatic ether, the S—O linkage and the 1,4 aromatic substitution.<sup>3</sup> NMR evidence confirms the presence of polysulfone. The characteristic resonances in the aromatic region (two sets of approximately AB quartets indicate units a and b in equal proportions). Moreover, the sharp singlet at 8.3  $\mu\text{m}$  is the same as the resonance due to

the  $\begin{array}{c} \text{CH}_3 \\ | \\ \text{—C—} \\ | \\ \text{CH}_3 \end{array}$  group in a sample of pure polysulfone (I):



The fractional composition shown in Table I was obtained as follows: polysulfone, by comparing the intensity at 8.65  $\mu\text{m}$  of a film of Arylon with a film of pure polysulfone; the acrylonitrile, the *trans*-1,4, and 1,2 unsaturation content by comparing the intensities of the peaks at 4.5, 10.3, and 10.9  $\mu\text{m}$ , respectively, with those of the same peaks in a film of ABS of known composition. The *trans*-1,4 and 1,2 unsaturation were found to be approximately 14% and 1.5% of the total polymer. From NMR, it was found that total 1,4 to 1,2 unsaturation was in the ratio 92:8, indicating that there was little *cis*-1,4 unsaturation.

The ABS employed for comparison was a grade (type 1) used previously in this program.<sup>1</sup> Its composition is given in Table I.

Films  $(10\text{--}15) \times 10^3$  nm were prepared as described before. They were exposed in the form of a sandwich, i.e., the transmission through one layer

TABLE I  
Composition of Polymers

|                         | Composition, wt-%                     |  |
|-------------------------|---------------------------------------|--|
|                         | Arylon                                | ABS  |
| Polysulfone             | 44                                    | 0  |
| Acrylonitrile           | 10                                    | 20   |
| Butadiene               | 16 (92% <i>trans</i> -1,4,<br>8% 1,2) | 25 (81.5% <i>trans</i> -1,4,<br>18.5% 1,2) |
| $\alpha$ -Methylstyrene | 28                                    | 0  |
| Styrene                 | 0                                     | 52   |
| Additives               | 2                                     | 3  |

was the incident radiation on the second layer, and so on. Four layers were used in the ABS.

Films were exposed outdoors at ERDE at an angle of 45° to the horizontal facing South over the period of September 14 to 29, 1970. Total solar radiation measurements were not made at ERDE during this period. The records of the London Weather Centre (kindly supplied by the Meteorological Office, Bracknell, Berks.) were therefore used in view of its close proximity to ERDE (16 miles).

## RESULTS AND DISCUSSION

As with ABS, the only changes observed in the infrared spectrum of Arylon as a result of weathering were the loss of unsaturation and the growth of hydroxyl and carbonyl groups. The loss in unsaturation (*trans*-1,4) as a function of incident total solar radiation is shown in Figure 2 for the two layers of the Arylon sandwich. The results for the four layers of ABS

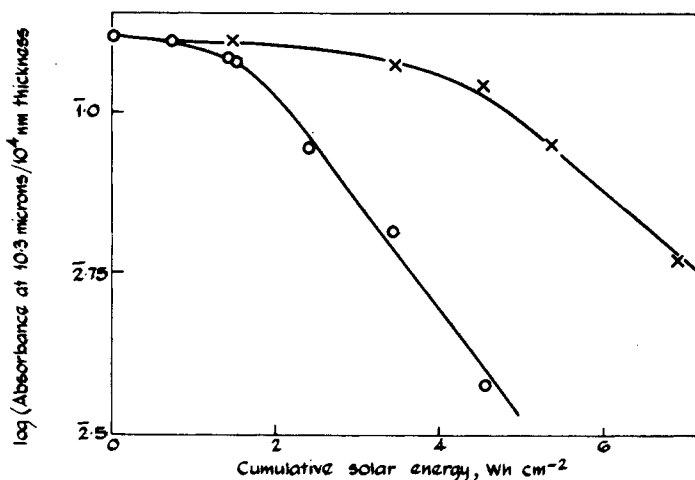


Fig. 2. Log-linear plot of change in *trans*-1,4 unsaturation with solar radiation for two films of Arylon exposed in sandwich form.

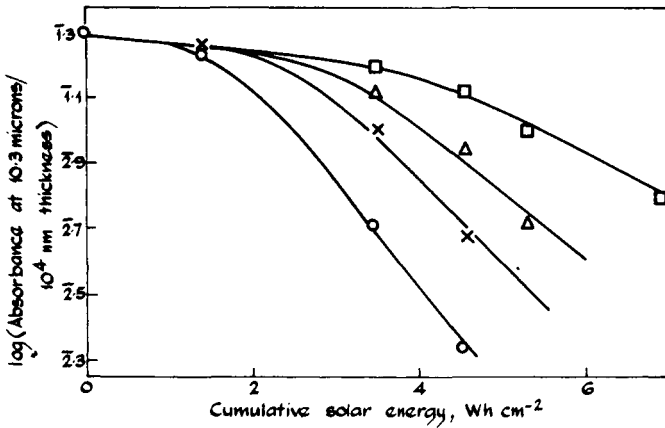


Fig. 3. Log-linear plot of change in *trans*-1,4 unsaturation with solar radiation for four films of ABS exposed in sandwich form.

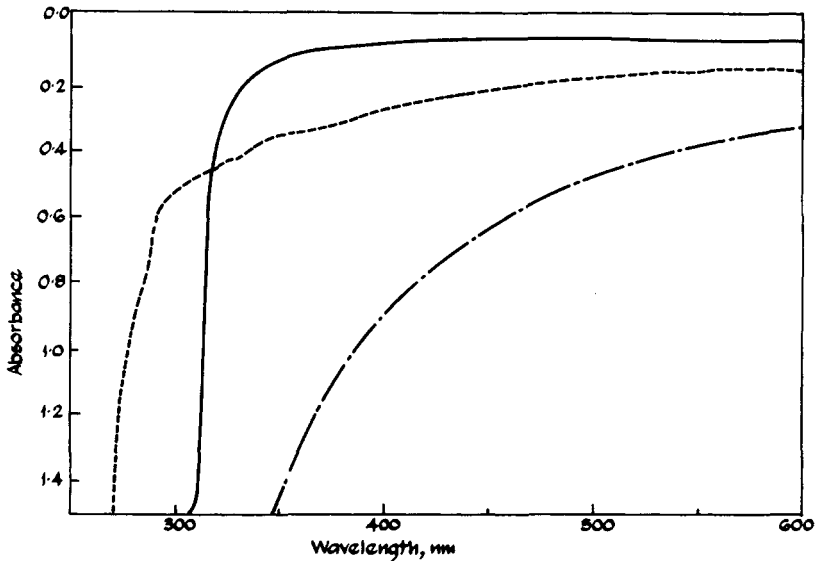


Fig. 4. UV transmission spectra for Arylon (— · —), polysulfone (——), and ABS (----)  $18 \times 10^3$ ,  $32 \times 10^3$ , and  $20 \times 10^3$  nm thick.

exposed at the same time as the Arylon are shown in Figure 3. The induction solar energies and the first-order rate constants for the various layers of Arylon and ABS obtained from Figures 2 and 3 are listed in Table II.

While the chemical features of degradation in Arylon and unblended ABS are similar, it is seen that their stabilities are significantly different both in terms of their induction solar energies and first-order rate constants. The first-order rate constants for the front layer are  $0.39$  and  $0.80 \text{ cm}^2(\text{Wh})^{-1}$  for Arylon and ABS, respectively. The probable reason for the difference in rate is that while both systems are optically heterogeneous,

TABLE II  
Induction Solar Energies and First-Order Rate Constants for Layers of  
ABS and Arylon

| Polymer | Layer | Induction<br>Solar Energy<br>Wh cm <sup>-2</sup> | First-Order<br>Rate Constant<br>cm <sup>2</sup> (Wh) <sup>-1</sup> |
|---------|-------|--|--|
| ABS     | 1     | 0.6  | 0.80   |
|         | 2     | 1.0  | 0.57   |
|         | 3     | 1.2  | 0.45   |
|         | 4     | 2.2  | 0.29   |
| Arylon  | 1     | 1.3  | 0.39   |
|         | 2     | 3.0  | 0.24   |

the incorporation of polysulfone with a high refractive index in Arylon results in a greater degree of light scattering in this material than in ABS. Light scattering would explain the tailing of the UV transmission spectrum and the fact that this spectrum bears little resemblance to the spectrum of the component of Arylon (Fig. 4)—if one makes the reasonable assumption that substituting  $\alpha$ -methylstyrene for styrene has no significant effect on the UV transmission spectrum. Hence, a significant amount of radiation, particularly in the region of 300–400 nm, which has been shown to be responsible for photo-oxidation, is probably reflected from the Arylon surface leaving the body of the film exposed to less radiation than that penetrating the ABS sample. It is probably for this reason also that the second layer of the Arylon sandwich is significantly less degraded (first-order rate constant  $0.24 \text{ cm}^2(\text{Wh})^{-1}$ ) than the second and third layers of the ABS material exposed for the same period.

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### References

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