Poly(acrylonitrile)/cellulose acetate/DMF 용액의 유변학적 특성 연구

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Rheological properties of poly(acrylonitrile)/cellulose acetate/DMF solution

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Introduction

Blending may be used effectively to modify the properties of polymer materials[1-3]. Some miscible polymer blends frequently produce really new properties which can not be obtained from the individual polymers, and fabricated articles give good mechanical properties. However, well established miscible polymer blends are very rare because of entropic hinderance of long polymer chains. Immiscible polymer blends generally have a coarse morphology, resulting in poor mechanical properties. If it is possible to obtain a highly dispersed mixture from immiscible polymers, fabricated articles may combine the properties of the respective component polymers[4]. Cellulose acetate(CA) is manufactured by many companies and easy to obtain. However it has poor hydrolytic stability and weak anti-oxidant ability. Briefly speaking, CA has drawbacks in the physical and chemical stability.
Poly(acrylonitrile)(PAN) has good material that has better physical and chemical stability because of the existence of nitrile groups on its macromolecular chain[5]. Blending of these two polymers may have interesting physical properties. In this experiment, N,N-dimethylformamide (DMF) was chosen as the cosolvent of PAN and CA, and the rheological properties of the PAN/CA/DMF blend solution were investigated in terms of blend composition and temperature.

Experiment

PAN (Aldrich Co., USA) and CA (Aldrich Co., USA), whose Mw were 140,000 and 50,000, respectively, were used. DMF were supplied by Duksan Co. (Korea). PAN/CA/DMF blend solutions with various compositions (table 1) were prepared by dissolving PAN and CA into DMF with stirring at 60 ℃ for 4 hours.

Table 1. Composition of Blend Solutions

Sample	Contents (wt%)		
	Total solid concentration	DMF	PAN/CA ratio
1	10	90	10/0
2	10	90	7/3
3	10	90	5/5
4	10	90	3/7
5	10	90	0/10

The rheological properties were measured by Advanced Rheometric Expansion System (ARES, Rheometric Co.). Parallel plate with 50 mm diameter at gap of 1 mm was used. The samples were loaded for 5 minutes at measuring temperature to release residual stresses. The strain level was 10% for all case. Dynamic frequency sweep test was carried out over the frequency range 0.05 ~ 500 rad/s at 40 and 50 ℃.

Results and discussion

Polymers cannot be mixed at an arbitrary ratio when the difference of their solubility parameters is more than 0.5 $(cal/cm^3)^{-2}$. The solubility parameters of PAN, CA and DMF are 15.4, 10.9 and 12.1, respectively[5]. Consequently, PAN and CA are thermodynamically incompatible. However, owing to the great viscosity of the blend solution and the slow movement of macromolecular chains, a dynamically stable blend solution can be obtained even if there is a tendency of phase separation.

Figures 1 and 2 present the dynamic viscosities of 10 wt% PAN/CA solutions at 40 and 50 ℃, respectively. Viscosities of pure PAN at 40 and 50 ℃ abruptly go down at the low frequency region. This tendency is less noticeable with increasing contents of CA up to 7/3. It shows that PAN has physical aggregation and forms pseudostructure by nitrile groups in PAN/DMF solution. Storage modulus (G′) and tan δ curves show that 5/5 PAN/CA solution gives rise to the highest G′ but shows a plateau region over three decades in tanδ response because the dipole-dipole interactions of PAN and rigid chain of CA exist compatibly.

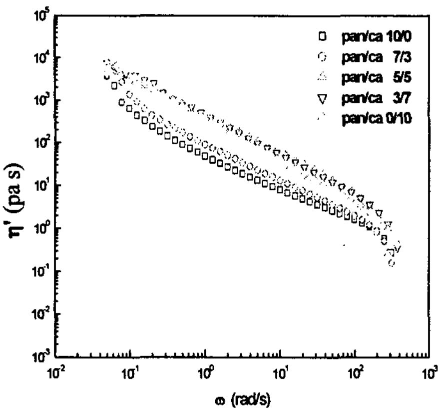

Figure 1. Dynamic viscosity curve of PAN/CA solutions in DMF at 40℃

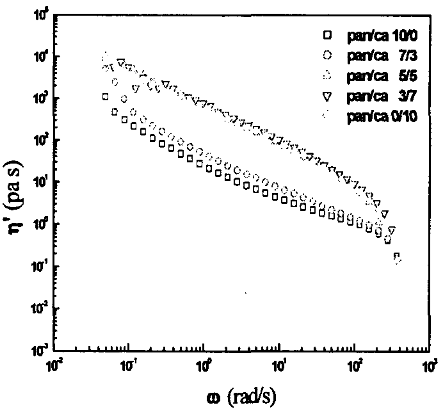

Figure 2. Dynamic viscosity curve of PAN/CA solutions in DMF at 50℃

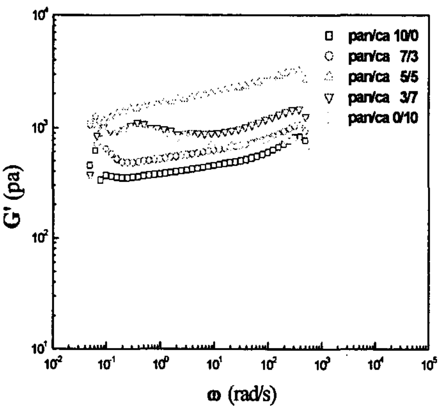

Figure 3. Storage modulus curve of PAN/CA solutions in DMF at 40℃

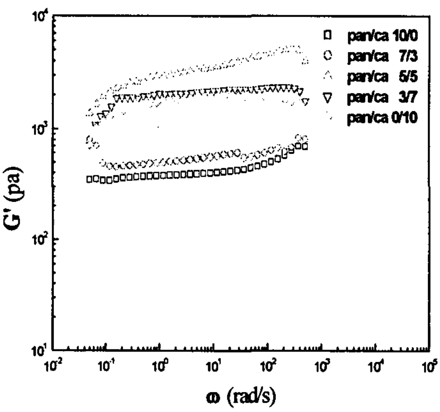

Figure 4. Storage modulus curve of PAN/CA solutions in DMF at 50℃

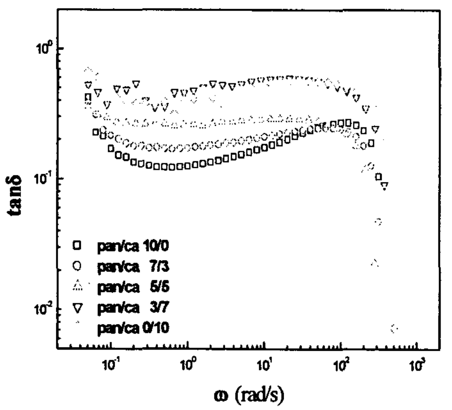

Figure 5. Tangent δ curve of PAN/CA solutions in DMF at 40℃

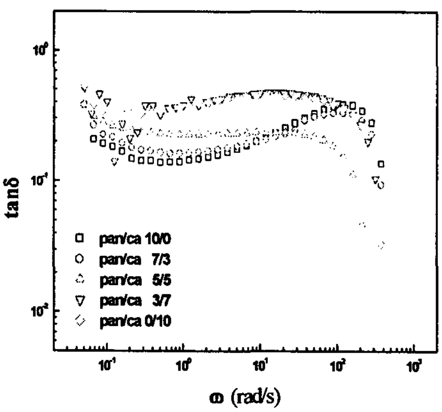

Figure 6. Tangent δ curve of PAN/CA solutions in DMF at 50℃

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