

Compatibilization of Polymer Blends from Poly(styrene-*co*-acrylonitrile) and Polycarbonate by Oxazoline Modification of Poly(styrene-*co*-acrylonitrile) in the Melt

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ABSTRACT: A good way of achieving compatibility in polymer blends of poly(styrene-*co*-acrylonitrile) (S/AN) and bisphenol A polycarbonate (PC) is the chemical modification of S/AN in the melt. A catalyzed reaction of the nitrile groups with a substituted 2-amino alcohol or 2-amino phenol resulted in a conversion of nitrile groups of 55–75% in 60 min. The introduced heterocyclic structures were ethyl hydroxymethyl oxazoline (EHMOXA) and benzoxazole (BenzOXA), respectively. The use of dibutyltin oxide as a catalyst led to the highest efficiency. The modified polymer was characterized by Fourier transform infrared and NMR spectroscopy, elemental analysis, and reactions with organic acids and anhydrides. The modified S/AN showed good technical compatibility (single glass-transition temperature)

with PC in blends made from solution and from the melt. All blends were characterized with oscillating rheometry and differential scanning calorimetry. Rheological measurements showed that EHMOXA-S/AN reacted with PC and had crosslinked structures, whereas BenzOXA-S/AN showed compatibilization without any (crosslinking) reaction. The melt blends of BenzOXA-S/AN and PC showed a downward shift in the complex viscosity due to the influence of the BenzOXA group. © 2003 Wiley Periodicals, Inc. *J Appl Polym Sci* 90: 2322–2332, 2003

Key words: melt; modification; blends; polycarbonates; compatibilization

INTRODUCTION

Polymer blends of poly(styrene-*co*-acrylonitrile) (S/AN) and bisphenol A polycarbonate (PC)

Because of their economic importance, blends of S/AN and PC have recently drawn a lot of scientific attention. The multifaceted field of applications for these blends runs from the automotive and electronic industries to multilayer systems.^{1–13} Blends of S/AN and PC are immiscible under normal conditions.^{14–17} Only a few exceptions are known in which both blend polymers have extremely low molecular masses.¹⁸ Likewise, there are results indicating that a single phase area in the miscibility map exists in which lower and upper critical solution temperatures appear simultaneously.^{16,19} The question concerning partial miscibility between the two polymers is answered in different ways. Reports of such partial miscibility^{15,16,20,21} have been explained by other workgroups to be the result of the influence of oligomer compounds.^{1,22,23} Nevertheless, it is obvious that immiscible blends with S/AN-24 [24 ma % acrylonitrile (AN)] and PC show the lowest

surface tension, the finest dispersion, and the highest surface adhesion,^{1,20,21,24,25} even if a temperature dependence of this phenomenon has been reported.¹⁶ This is due to thermodynamic interactions between the two polymers, which show a local maximum at 25 ma % AN within S/AN.^{18,26,27} As in other S/AN blends [e.g., poly(styrene-*co*-maleic anhydride)], intermolecular repulsion has also been claimed to be the reason for the phase behavior of S/AN-PC blends.²⁸ Blends of S/AN and PC show cocontinuous structures with PC contents between 40 and 70 ma %, ^{29,30} a wide range of additivity in the temperature-dependent rheological values,³¹ and a positive deviation from the additivity of the frequency dependence of the storage and loss moduli. Despite their immiscibility, unmodified blends of S/AN and PC are among the most successful multiphase materials in the automotive and electronic industries.^{1–6} The main problem of S/AN-PC blends is their tendency to coalesce during processing, which can result in coarse structures and inferior material properties.^{8–12} Even short downtimes at a processing temperature of 270°C (e.g., in injection-molding machines) can cause a significant deterioration of the morphology.³² A good strategy for lowering the surface tension between two polymers is the *in situ* introduction of chemical bonds between the two phases.³³ There have been several attempts to stabilize S/AN-PC blends, mainly with block copolymers of PC and poly(methyl methacrylate),²⁵ terpolymers of methacrylate, butadiene, and styrene,³³ or terpolymers

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of styrene, amine-functionalized maleic anhydride, and AN.^{11,12,34} Even modified PC,³⁵ aliphatic polyesters, and polyamide 6 (PA-6)^{36–38} have been used to compatibilize S/AN-PC blends.

Blend compatibilization with oxazolines

Even if oxazoline polymers can be synthesized directly, for example, from vinyl oxazoline,³⁹ polymers with oxazoline groups are commonly synthesized through graft reactions or polymer modification. Oxazoline-functionalized polymers have often been used as reactive compatibilizers in polymer blends because of their high reactivity toward amino, carboxyl, anhydride, and hydroxy groups.⁴⁰ For example, the problem of immiscibility in blends of polyolefins with polyesters and polyamides can be solved with oxazoline functionalization (grafting) of the polyolefin. Blends of oxazoline-grafted polypropylene (PP) and poly(butylene terephthalate) show a better dispersion of the blend polymers, a higher surface adhesion, and a better impact strength.^{41,42} Blends of oxazoline-grafted PP and PA-6 show similar results according to the morphology and better mechanical properties.⁴³ In addition to grafting reactions, oxazoline functionalities can also be introduced through analogous polymer reactions. In this way, functional groups of technical and engineering polymers are converted into heterocyclic functionalities. One possibility is the reaction of nitrile polymers with 2-amino alcohols in solution^{44,45} or in the melt.^{46–49} Oxazoline-functionalized poly(butadiene-*co*-acrylonitrile) from analogous polymer reactions has been used as a compatibilizer in blends with polyesters⁵⁰ and PA-6.⁴⁸ Even S/AN and ABS can be functionalized in this way and used as compatibilizers in blends with polyesters and polyamides,^{46,49} but until now no such use has been reported for polycarbonate blends. It should be mentioned that a high degree of functionalization can lead to crosslinking effects during the compatibilization process, which can affect the mechanical properties.⁵⁰

EXPERIMENTAL

Materials

The polymers and amino alcohols and their properties are listed in Table I (polymers) and Table II (amino

TABLE II
Amino Alcohols Used for the Polymer Modification and Their Characteristics

Material	M (g/mol)	K_p (°C)
AEPD	119,16	265
oAP	109,13	175 (melting temperature)

alcohols).

As catalysts for the polymer modification process, we used cadmium acetate [Cd(Ac)₂], zinc acetate [Zn(Ac)₂], zinc stearate, itaconic acid, and dibutyltin oxide (DBTO). All amino alcohols and catalysts were purchased from Aldrich and used without further purification.

Introduction of the heterocyclic functionality

The chemical modification in the melt was performed in Brabender melt kneaders with capacities of 30 (W30-EHT) and 50 cm³ (W50-EHT). As the initial mixing temperature, we chose 190°C because it would result in higher degrees of conversion than the temperature of 160°C chosen by other workgroups.⁴⁶ The rotation speed of the mixing rotors was 35 rpm. To achieve a homogeneous mixture, we melted the granulated polymer (S/AN) for 3 min, added the catalyst, and mixed the mixture 2 min more. The results of the catalyst mixing differed quite a bit because of the big differences in the material properties of the catalysts. For example, at 190°C, zinc stearate is a liquid with a very low viscosity, whereas DBTO remains solid. Despite the possible inhomogeneity of the polymer-catalyst mixture, DBTO can be dissolved in phenols and diols because of the (reversible) formation of cyclic structures.^{51,52} Similar reactions are known for zinc salts, which are able to form complexes with amino and hydroxyl functions.⁵³ Because of this, we expected the former inhomogeneous reaction mixture to reach a homogenous state after the addition of the amino alcohol. The addition of the amino alcohol also started the reaction between the nitrile group and the amino alcohol. The same amount of polymer was used for all experiments (depending on the capacity of the kneader chamber), whereas the amounts of the amino alcohol and catalyst were varied. The reported batch ratios are molar ratios of the AN groups, additive groups, and catalyst. The samples were purified by their dissolution in acetone followed by precipitation in methanol or methanol-water mixtures. The purification procedure was carried out at least twice. The precipitated samples were first dried for 24 h at room temperature, then for 48 h at 70°C, and finally at 70°C *in vacuo* (<20 mbar) until a constant weight was reached. The results of the purification were monitored by Fourier transform infrared (FTIR) spectroscopy.

TABLE I
Polymers Used and Their Characteristics

Material	Source	M_n (g/mol)	T_g (°C)
S/AN, Sconarol (38 mol % AN)	Buna AG	102.000	113
PC, Macrolon 3103	Bayer AG	–	153

M_n = number-average molecular weight; T_g = glass transition temperature.

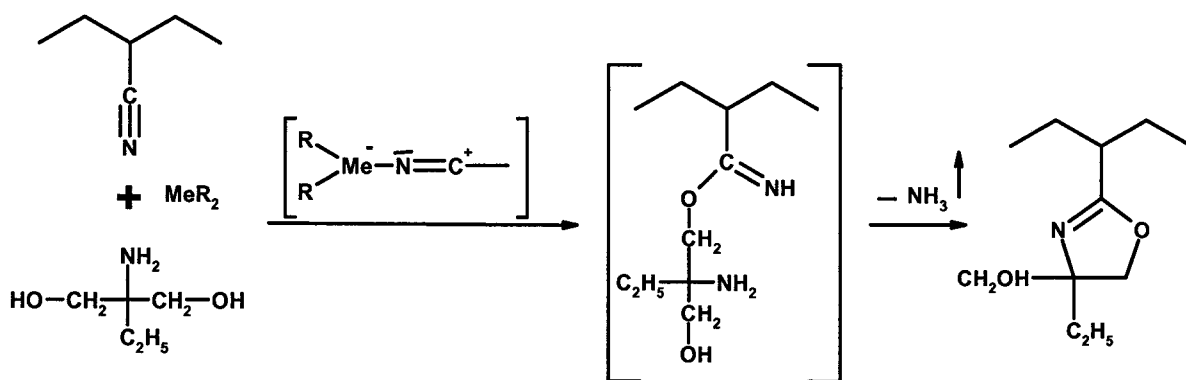


Figure 1 Reaction of a polymeric nitrile group with AEPD under catalysis with MeR_2 .

copy (5-DXB, Nicolet) and elemental analysis (Elementar Analysensysteme, Vario EL). The nitrile conversion was determined qualitatively with FTIR, $^1\text{H-NMR}$ (DPX 200, Bruker; CDCl_3 and 200 MHz), and $^{13}\text{C-NMR}$ spectroscopy and quantitatively with elemental analysis with CHNO detection (as discussed later).

Blending of the polymers

Blends were made from solution and in the melt. In addition to the purification, all blend polymers were dried at least 24 h *in vacuo* (<20 mbar) at 70°C to prevent hydrolytic effects from moisture. For the melt blending, the chosen amounts of the blend partners were premixed before being placed into the Brabender mixer (30 cm^3) at 250°C for 10 min. Blends were made with ratios of 20:80, 50:50, and 80:20 (ma %). The samples were kept under a dry atmosphere until the analysis. The solution blends were made out of 5 ma % solutions in chloroform. The solutions were mixed at room temperature for 15 min and then precipitated into methanol. The precipitated samples were first dried for 24 h at room temperature, then for 48 h at 70°C , and finally at 70°C *in vacuo* (<20 mbar) until the weight was constant. The characterization of the blends was performed with thermal analysis and oscillating rheometry. A DSC 820/25 instrument from Mettler-Toledo was used for the thermal analysis of the samples. Each sample (10 mg) was taken and pressed into a disc. The sample was heated to 200°C and cooled again to 25°C (N_2 flow = 50 mL/min) to eliminate the effects of thermal history. Only the second heating process (20 K/min) was used for the thermogram from which the glass-transition temperature (T_g) was determined. For the rheological measurements, we used an RDA II dynamic analyzer from Rheometrics Scientific with a plate-plate geometry. Each sample (140 mg) was pressed into a disc (13 mm in diameter and 1 mm thick) and inserted at room temperature. The region of linear viscoelasticity was checked first for all samples (dynamic strain sweep).

All further measurements were solely carried out in the region of linear viscoelasticity. The thermorheological properties were determined through temperature ramp tests (frequency = 6.28 rad/s) in a temperature range of $250\text{--}60^\circ\text{C}$ at cooling rates of 2 K/min . The frequency dependence of the rheological properties was determined through dynamic frequency temperature sweeps with a frequency range of $100\text{--}0.05\text{ rad/s}$ and temperature steps of 5 or 10 K. Master curves were generated with Rhios 4.3.2 software and a reference temperature (T_R) of 170°C ($T_{g,\text{max}} + 15\text{ K}$) with at least four different frequency sweeps.

RESULTS AND DISCUSSION

Introduction of the heterocyclic functionality

The reaction of nitriles with 2-amino alcohols, leading to oxazolines, was first studied by Witte and Seeliger.⁵⁴ The reaction must be catalyzed by Lewis acids for high yields to be achieved (Fig. 1).

The transformation of this reaction into polymer chemistry (with S/AN), which was accomplished by Hseigh and coworkers^{44,45} for a solution process, yields only small degrees of conversion (nitrile groups) of about 10–30% in up to 9 h. In the melt, Hu et al.⁴⁶ reported conversion degrees of only 1.5–14% in 60 min. Principally, the reaction in the melt as a solvent-free process is more advantageous because of the possibility of online processing, for example, by the use of extrusion processes, which leads to major time and cost savings. Additionally, there are economic and ecological advantages that result from the lack of solvents (solvent removal and energy costs). The problem is that the use of short aliphatic amino alcohols in the reaction with nitrile groups only leads to low amounts of oxazoline groups in the polymer.

The use of a substituted aliphatic 2-amino alcohol [2-amino-2-ethylpropane-1,3-diol (AEPD)] or 2-amino phenol (oAP) produces higher yields in shorter reaction times in comparison with those found in the reaction of aliphatic or aromatic nitriles and amino alcohols (Fig. 2).

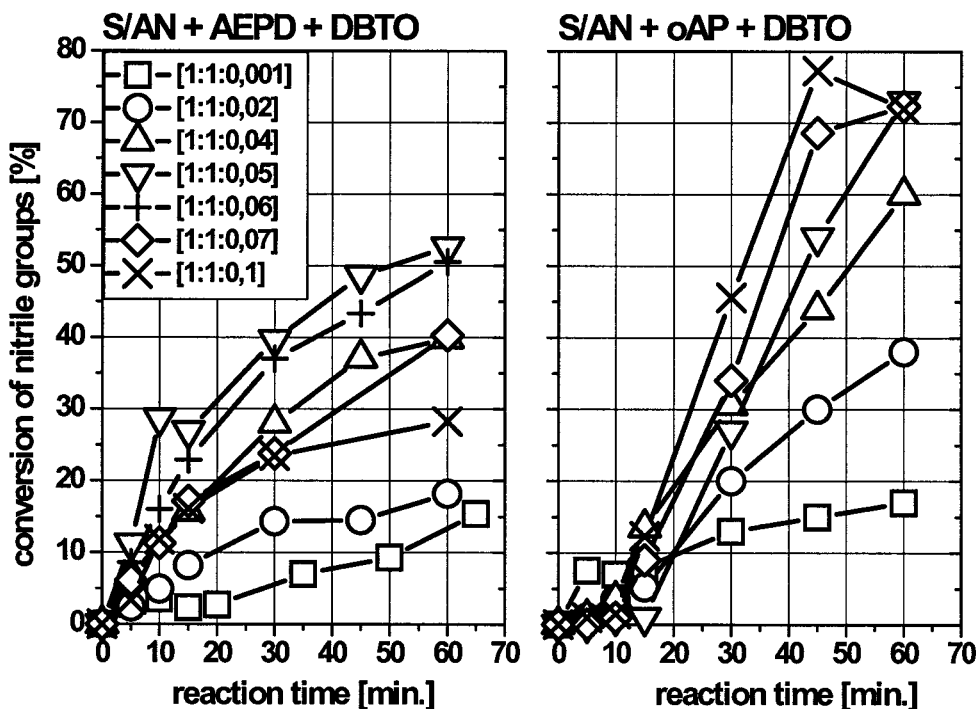


Figure 2 Conversion of nitrile groups (S/AN) versus the reaction time and batch ratio in reactions of S/AN with AEPD, oAP, and DBTO. The batch ratios were (□) 1:1:0.001, (○) 1:1:0.02, (△) 1:1:0.04, (▽) 1:1:0.05, (+) 1:1:0.06, (◇) 1:1:0.07, and (×) 1:1:0.1.

With AEPD, conversion rates (nitrile groups) of up to 55% can be achieved in only 60 min, whereas the use of oAP yields up to 75% converted nitrile groups in the same time. The conversion rate and reaction velocity strongly depend on the concentration of the catalyst and the batch ratio. Although a higher catalyst concentration leads to a higher reaction velocity and even higher degrees of conversion in reactions with oAP, the reactions with AEPD show a maximum conversion degree and maximum reaction velocity at a batch ratio of $[AN]/[AEPD]/[DBTO] = 1:1:0.05$. A higher catalyst concentration leads to lower conversion degrees and a lower reaction velocity because of the side reaction between AEPD and DBTO, which results in cyclic structures.⁵² Because the reaction requires the presence of a catalyst, those most commonly used are $Cd(Ac)_2$, $Zn(Ac)_2$, and zinc chloride. We have found that the use of DBTO as a catalyst yields larger amounts of converted nitrile groups than the commonly used catalysts but requires higher reaction temperatures. Even itaconic acid and zinc stearate can be used as catalysts (Fig. 3).

The catalysts $Cd(Ac)_2$ and $Zn(Ac)_2$ show comparable results with both additives. In reactions of S/AN with oAP, itaconic acid leads to high yields, but it leads to poor yields in reactions of S/AN with AEPD. With zinc stearate, acceptable results can be obtained for the S/AN–oAP system, whereas the yield for the S/AN–AEPD system is poor. The differences can be explained by mixing problems between the catalyst

and the polymer melt. With both additives, DBTO shows the highest catalytic efficiency.

The determination of the nitrile conversion can be performed qualitatively with FTIR and NMR spectroscopy. The modified polymer shows new peaks in FTIR and NMR spectra (Table III) that belong to new structural elements such as $-C=N-$ and $-C-O-C-$ and the introduced methyl and methylene structures. The FTIR and 1H -NMR data are in good agreement with the data obtained from other workgroups for similar reactions.^{48,50} The ^{13}C -NMR data for benzoxazole (BenzOXA)-modified S/AN are also in good agreement with data in the spectroscopic literature.

Through an elemental analysis of the oxygen content, the conversion of the nitrile groups (U) can be calculated with a simple equation that presumes that side reactions have no influence on the oxygen content of the purified samples:

$$U(\%) = \frac{\xi_{O,Product}}{0.0045121 \frac{\text{Mol of nitrile}}{g} [XM_o - \xi_{O,Product}] \times (XM_o + YM_c + ZM_H)} \quad (1)$$

where $\xi_{O,Product}$ is the oxygen content of the product; X , Y , and Z are the numbers of oxygen, carbon, and hydrogen atoms, respectively, additionally present in the product (with respect to the unmodified struc-

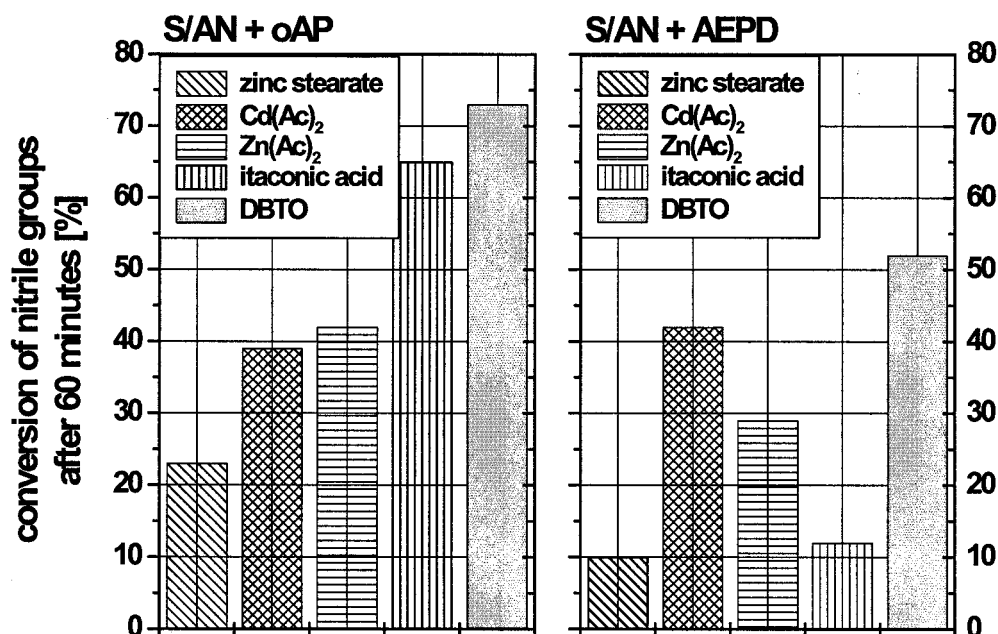


Figure 3 Maximum conversion (after 60 min) in reactions of S/AN with AEPD or oAP with various catalysts ([AN]/[additive]/[catalyst] batch ratio = 1:1:0.05).

ture); and M_O , M_C , and M_H are the molar masses of the atoms.

The calculated degree of conversion can be used to calculate the theoretical amounts of carbon, nitrogen, and hydrogen in the products. Comparing these data

with the corresponding data of the elemental analysis shows good agreement (Table IV).

The reactivity of the products obtained has been proven in reactions of the modified polymer with benzoic acid, methacrylic acid, maleic anhydride, and

TABLE III
Spectroscopic Data of the Modified Polymer

Product structure	New FTIR signals	New NMR Signals
	3530 cm^{-1} (—OH) 1660 cm^{-1} (—C=N—) 1270 cm^{-1} (—C—O—C—) 1005 cm^{-1} (skeletal vibrations)	¹ H-NMR 1.816 ppm; (m) (methyl/methylene protons: [7 + 8]) 2.167 ppm; (s) (methin proton: [*]) 3.743 ppm; (m) (methyl/methylene protons [5 + 6]) ¹³ C-NMR: 52.5 + 68.4 ppm; (methylene carbons [4 + 5])
	1685 cm^{-1} (—C=N—) 1612 cm^{-1} (—C=C—) 1570 cm^{-1} (—C=C—) 1230 cm^{-1} (—C—O—C—) 1003 cm^{-1} (skeletal vibrations)	¹ H-NMR 7.482 ppm; (m) (aromatic protons) ¹³ C-NMR 110.8 ppm; [9] 123.5–125.5 ppm; aromatic carbons 141.5 ppm; [4] 150.6 ppm [2]

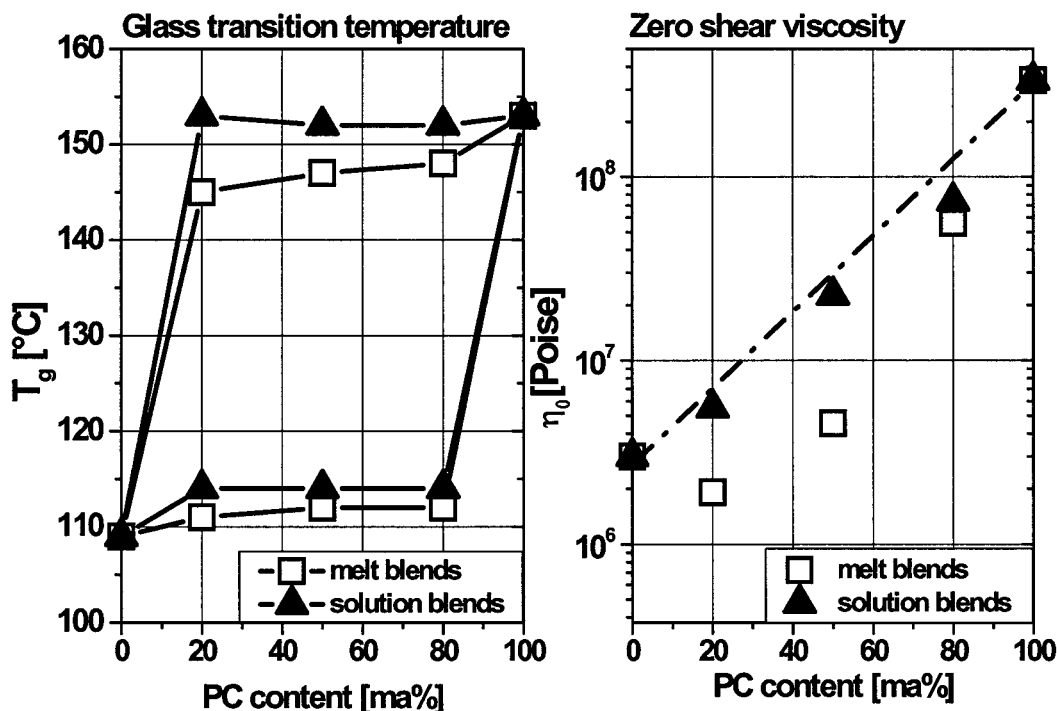


Figure 4 T_g 's and zero-shear viscosities (from master curves at 180°C) of (□) unmodified melt and (▲) solution blends of S/AN and PC.

itaconic acid in solution (solvent = *N*-methyl pyrrolidone; temperature = 170°C; time = 6 h). Although the products yielded from ethyl hydroxymethyl oxazoline (EHMOXA)-S/AN reactions show new peaks in FTIR spectra with all four agents at 1730 and 1650 cm^{-1} due to the ester-amide formation, no such peaks have been found with BenzOXA-S/AN because of the high stability of the aromatic system. The ester-amide peaks found are in good agreement with the results reported by Hu et al.⁴⁶ and Bruch et al.⁵⁵ for similar reactions. Because of its low reactivity, we expected the BenzOXA product to show a totally different behavior if used as a compatibilizing agent in polymer blends.

Compatibilizing S/AN-PC blends

For the blends, we used EHMOXA-S/AN and BenzOXA-S/AN with conversion rates (nitrile groups) of 50 and 70%, respectively. The blends were obtained from both polymer melts and solutions. Blends with three different concentrations of PC (20, 50, and 80 ma %) were produced and analyzed with differential scanning calorimetry and oscillating rheometry. A single T_g and a single $\tan \delta$ maximum (loss factor) were taken as signs of a compatible blend. First, blends with unmodified S/AN were analyzed to obtain reference data. In total agreement with the results of Guest and Daly,²² Belloch et al.,²³ and Driscoll and Benoit,³¹ we found no sign of partial miscibility of the two blend

partners if the oligomer parts were removed, as done in the solution blending (Fig. 4).

All of the unmodified blends obtained from solution blending/precipitation show two T_g 's that are independent of the blend composition. The zero-shear viscosity of the blends shows linear additivity. Only the melt blends in which the oligomeric parts are still present show a dependence of both T_g and the zero-shear viscosity on the blend composition.

The solution blends with EHMOXA-S/AN show two T_g 's (and two $\tan \delta$ maxima) for a PC content of 50 ma % but only one T_g (one $\tan \delta$ maximum) for 20 and 80 ma %, whereas all melt blends show a single T_g (one $\tan \delta$ maximum) only (Fig. 5). That means that in solution, an excess of oxazoline or carbonate groups results in compatibility, whereas equal amounts of both do not.

Although the ring-opening reaction between oxazoline and hydroxy groups⁵⁰ appears to be of little importance for blends obtained from solution because of the low blending temperature, there are other possibilities for interactions between the two blend polymers, such as hydrogen bonds between the free hydroxy group of the oxazoline and the carbonate functionalities of PC.⁵⁶ In the melt, the reaction between the oxazoline functionality of modified S/AN and the hydroxy groups of PC should proceed fast and to a high degree, resulting in covalent bonds between the two phases. The reaction can cause crosslinking if the

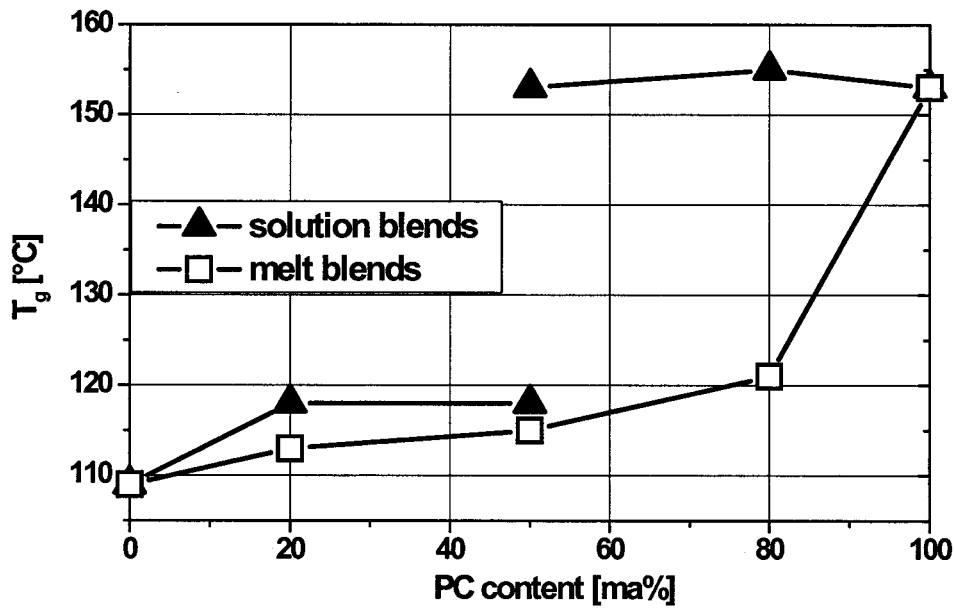


Figure 5 T_g 's of (□) melt and (▲) solution blends of EHMOXA-S/AN and PC with different PC contents.

two hydroxy end groups of PC react with different modified S/AN chains, and this results in a solidification of the material. The occurrence of this reaction can clearly be shown through rheological measurements (Fig. 6).

Blends from both methods show different behaviors than the unmodified blends. All melt blends show a storage modulus that is nearly independent of the frequency. This is a clear indication for crosslinked structures in the samples. The solidification of the

material is shown as a strong rise of the storage modulus. The higher the PC content is in the blend, the higher the storage modulus is. For the solution blends, a clear dependence of the storage modulus on the frequency can be observed that suggests that there are fewer (or no) crosslinked chains in the samples.

At first glance, the results of the BenzOXA-S/AN blends appear similar to those of the EHMOXA-S/AN blends; the blends from solutions with 20 and 80 ma % PC show only one T_g , whereas the blend with 50 ma %

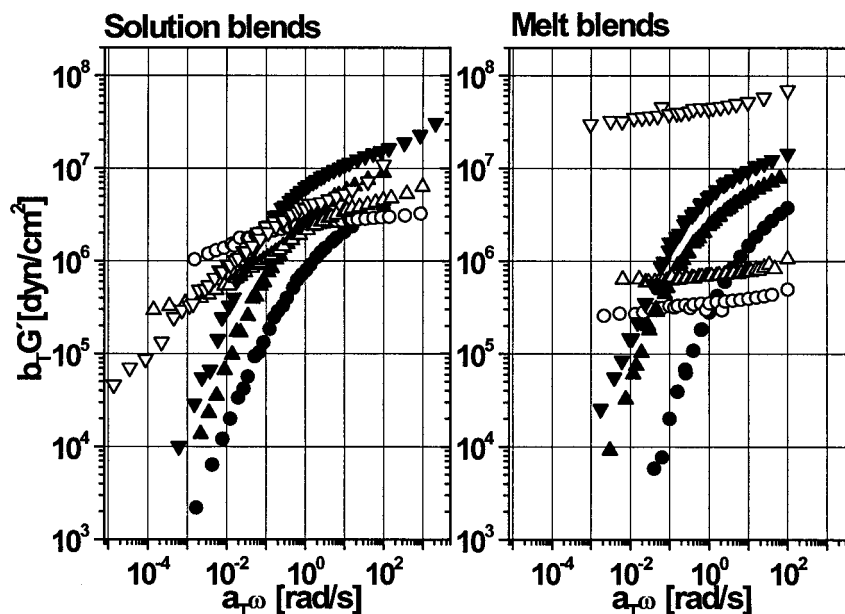


Figure 6 Dependence of the storage modulus (G') on the frequency for melt and solution blends of unmodified S/AN, EHMOXA-S/AN, and PC (from master curves at $T_R = 170^\circ\text{C}$). The X/PC sample ratios were (●) 80:20 (unmodified), (○) 80:20 (modified), (▲) 50:50 (unmodified), (△) 50:50 (modified), (▼) 20:80 (unmodified), and (▽) 20:80 (modified).

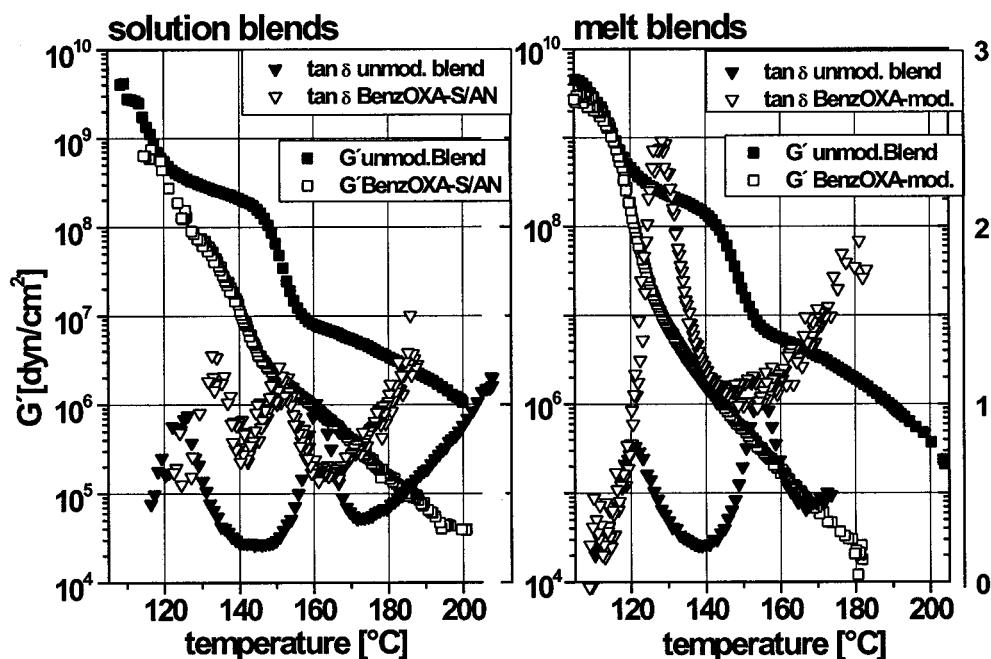


Figure 7 Dependence of the (■) unmodified and (□) modified storage modulus (G') and the (■) unmodified and (□) modified loss factor ($\tan \delta$) on the temperature for solution and melt blends (50:50) of unmodified S/AN, BenzOXA-S/AN, and PC.

PC shows two. All melt blends show only one T_g . The difference between the melt and solution blends is due to the fact that no reaction occurs between the components because of the high stability of the BenzOXA structure. There are also no free hydroxyl groups (as in EHMOXA-S/AN) or any other reason that the melt blends should perform better in compatibilization. Nevertheless, the difference in the thermorheological behavior of the two blends with 50 ma % PC is that the solution blend shows two $\tan \delta$ maxima, whereas the melt blend shows only one (Fig. 7).

For both samples, a shift of the storage modulus to lower values can be observed. This can indicate a drop in the surface tension resulting from the interaction between the two blend partners. Even if the solution blend shows a shift in $\tan \delta$, there are actually two maxima indicating two separated phases. Contrary to this, the melt blend has only one $\tan \delta$ maximum situated right between those from the unmodified blend, and this indicates that the compatibilization of the two phases has taken place. The difference between the two results can only be explained as an effect of the blending temperature, which differs by more than 220 K. Instead of being two-phased, the solution blends show a clear influence of the modification on the rheological properties of the samples, particularly a divergence from the additivity of zero-shear viscosity (Fig. 8).

In comparison with the unmodified blends, there is a clear drop in the zero-shear viscosity of the modified blends as a result of the interactions between the blend

partners. There are several opportunities for interactions, including π - π interactions between the aromatic systems of the BenzOXA groups of the modified S/AN and the bisphenol A components of PC. Another possible explanation is the influence of the BenzOXA structure on the intramolecular repulsion of S/AN. A lower zero-shear viscosity means that the polymer melt flows more easily at lower temperatures and can be processed better. This is advantageous for shape-giving processes such as injection molding. A similar effect can also be observed for the melt blend with 50 ma % PC, which shows a drop in all rheological parameters (Fig. 9).

The master curve shows a good coherence between the temperature curves (especially $\tan \delta$), indicating that the TTS principle can be used for creating the master curve.⁵⁷ As for the solution blend, there is also a significant drop in viscosity resulting in better processability of the material.

Another way of determining the difference between the two compatibilization processes with EHMOXA-S/AN and BenzOXA-S/AN consists of rheological measurements with a hysteresis-like temperature program. Equal amounts of the two blend partners are mixed in a mill and then formed under pressure into a disc-shaped sample. This sample is placed in an oscillating rheometer and subjected to a special temperature ramp program under which the temperature is first increased to 180°C; this is followed by a short isotherm period, the temperature is lowered to 100°C, and so forth. During this temperature program, the

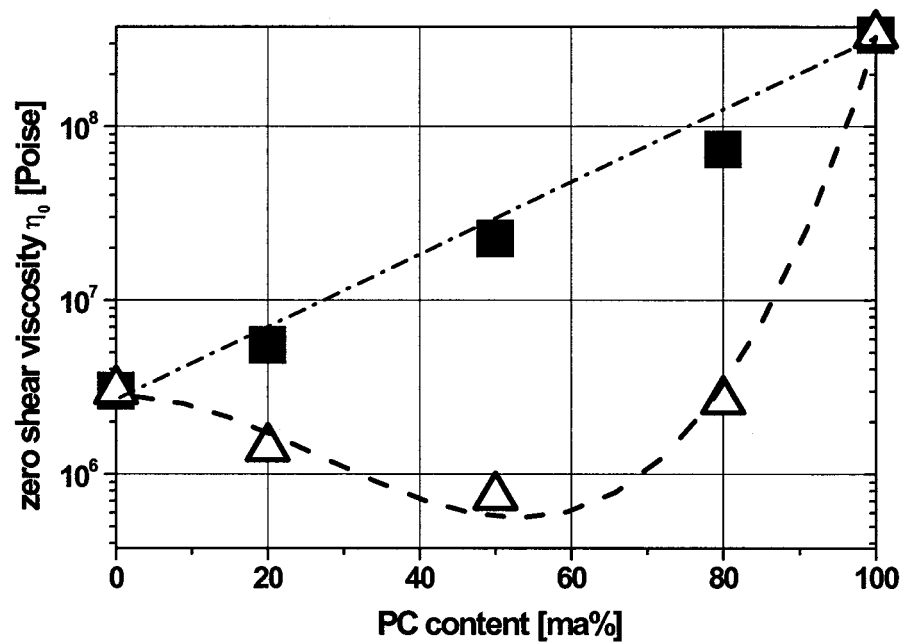


Figure 8 Dependence of the zero-shear viscosity on the PC content of solution blends of unmodified (■) S/AN, (△) BenzOXA-S/AN, and PC (170°C).

rheological properties are measured with low strain measurements (Fig. 10). Low strain means that no mixing of the sample occurs during the measurements. The observed effects can only result from surface reactions between the two mixed powders. $\tan \delta$ is an especially good indicator for showing if any interaction between the two blend partners has taken place.

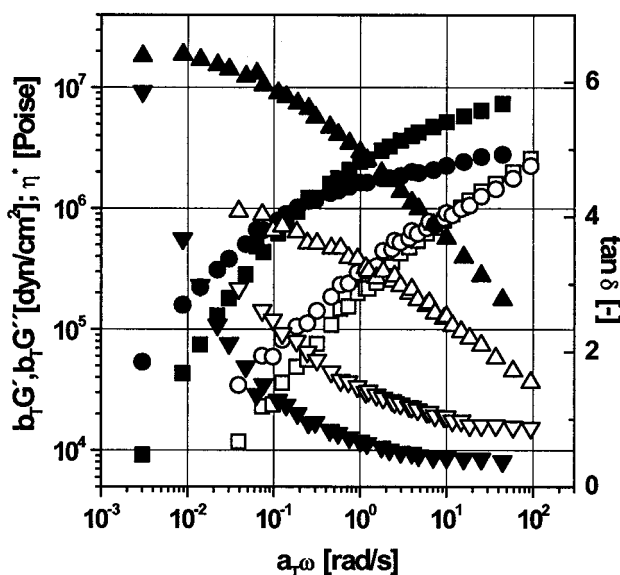


Figure 9 Dependence of the storage modulus (G'), loss modulus (G''), viscosity (η^*), and loss factor ($\tan \delta$) for melt blends of unmodified S/AN (solid symbols), BenzOXA-S/AN (open symbols), and PC (from master curves at $T_R = 170^\circ\text{C}$): (■, □) G' , (●, ○) G'' , (▲, △) η^* , and (▼, ▽) $\tan \delta$.

For EHMOXA-S/AN, there are two maxima in the first heating step and afterward only one maximum, and this suggests a fast reaction between the two polymers. This result indicates that it should be possible to use EHMOXA-S/AN even in coextrusion processes because the adhesion of, for example, two extrusion profiles is required. With BenzOXA-S/AN, there are always two maxima, indicating that no compatibilization can be achieved with BenzOXA-S/AN without the proper mixing of the two polymers.

CONCLUSIONS

When substituted 2-amino alcohols and oAPs are used together with efficient catalysts, the nitrile groups of S/AN can be converted into heterocyclic functionalities with high degrees of nitrile conversion and short reaction times through analogous polymer reactions in the melt. The S/AN modifications can be used for blend compatibilization in S/AN-PC blends in solution and in the melt. Although the compatibilization process with EHMOXA-S/AN is based on a fast reaction between the oxazoline functionality and the hydroxy groups of the PC, resulting in covalent bonds between the two polymer phases, BenzOXA-S/AN shows another kind of interaction without a covalent phase connection. In both cases, melt blends of all ratios show compatibilization, whereas blends from solution show compatibilization with PC contents of 20 and 80 ma % only. Although the reaction between EHMOXA-S/AN and PC is very fast and even possible as a surface reaction, for BenzOXA-S/AN, a high

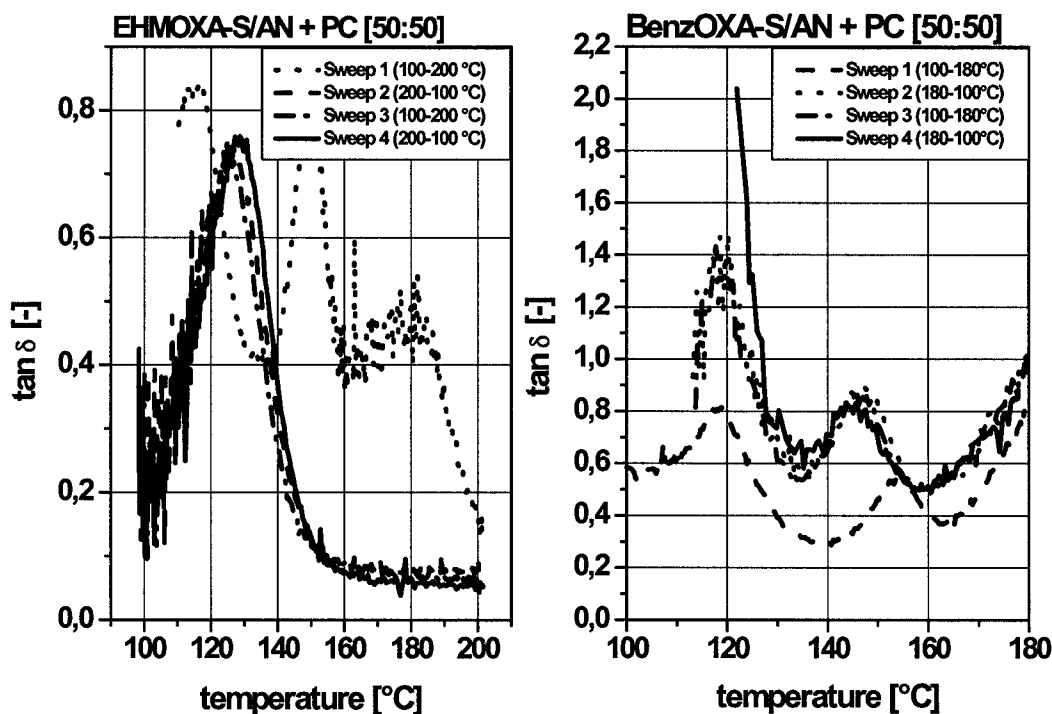


Figure 10 Reactive (hysteresis) measurements in oscillating rheometry (two heating and two cooling sweeps). The loss factor ($\tan \delta$) is dependent on the temperature for a powder mixture of EHMOXA-S/AN, BenzOXA-S/AN, and PC (50:50).

temperature and good mixing are required to achieve good compatibilization results. The resulting materials show lower melt viscosities and better processability than their unmodified counterparts, and this is advantageous in injection-molding processes, for example. In further investigations, we will transfer our results from S/AN to ABS polymers to achieve better compatibility in ABS/PC blends.

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