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Using bis-oxalamides to reduce the haze of linear low-density polyethylene

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The haze of a commercially available resin can be reduced by up to 50% by incorporating novel clarification agents.

Semicrystalline polymers, such as polypropylene (PP) and polyethylene (PE), are naturally translucent or opaque because their crystals aggregate into large complexes that are known as spherulites.[1–4] The presence of these spherulites—because their size is normally larger than the wavelength of visible light—causes light scattering and high amounts of haze (the portion of visible light scattered at wide angles) in these materials. Increasing the transparency of semicrystalline polymers has thus been of interest for several decades (i.e., to improve the commercial value of the polymers).[5]

It has previously been demonstrated that clarifying agents—special types of nucleating agents—can be used to reduce crystal size, through the creation of 'extra' nucleation sites upon which spherulites can grow.[6–9] Although there have been many studies of clarifying agents for isotactic PP,[6, 7, 10, 11] there has been little research on the clarification of PE. Such an investigation could thus increase fundamental understanding of PE nucleation in the presence of clarifying agents and potentially increase the value of this material.[12–15]

In our recent work,[16] we therefore studied the structure–property relationship in a series of *bis*-oxalamide compounds. We chose these compounds because it has previously been reported that they exhibit strong clarifying effects for semicrystalline polyolefin.[17] Specifically, we investigated how the compounds influenced the clarification of a commercially available linear low-density PE (LLDPE). To that end, we synthesized our *bis*-oxalamide compounds with different core and pendant groups (see Table 1) and then blended them with the LLDPE resin (DOWLEX™ 2045G) at different concentrations.

To initially evaluate the clarifying effect of our *bis*-oxalamide compounds, we measured the haze (which, as a measure of a sample's turbidity, is lower for more transparent materials) of 1.5mm-thick injection-molded LLDPE discs that contained the *bis*-oxalamide compounds at concentrations of 0.1–2wt%. The overall haze values for each sample are shown in Figure 1. Among all the compounds we tested, N5 (see Table 1) exhibits the best clarification performance. Our results show that the haze values reduced with increasing concentrations of N5, until the minimum haze level (50%) was reached at the additive concentration of 0.2%.

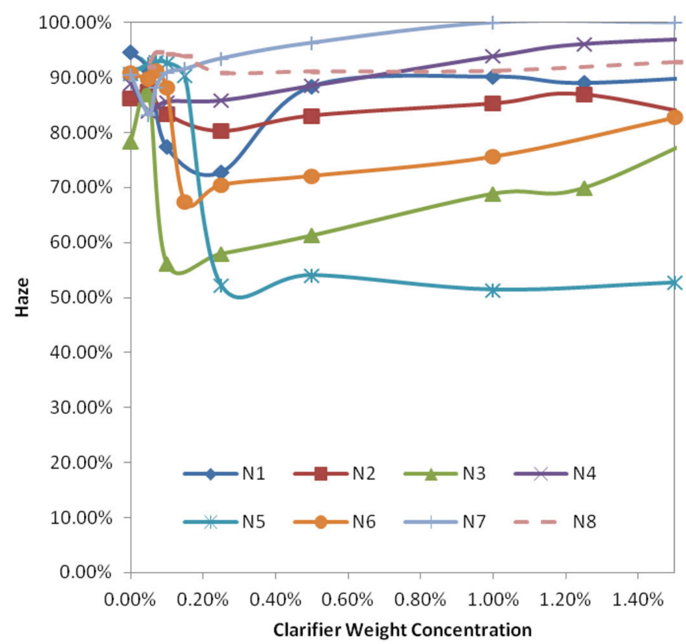

Figure 1. *Haze values for 1.5mm-thick linear low-density polyethylene (LLDPE) discs that contain bis-oxalamide compounds (N1–N8: see Table 1) at concentrations of 0–1.4wt%.*

On the basis of the 1.5mm disc results, we chose to also measure the haze of 50μm-thick blown films of LLDPE that contained the N5 compound at concentrations of 0, 1000, and 2000 parts per million (ppm). Compared with the neat LLDPE sample, we observed (see Figure 2)

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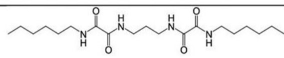
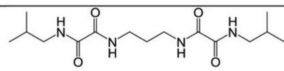
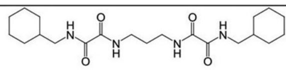
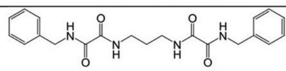
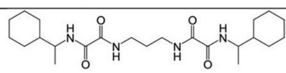
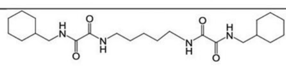
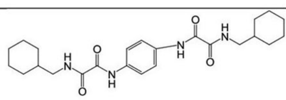
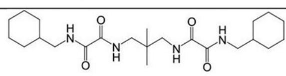
Table 1. The molecular structure, molecular weight, melting temperature, and crystallization temperature of the eight bis-oxalamide compounds (N1–N8) studied. Each of the compounds contains different core and pendant groups in its molecular structure.

Compound	Molecular structure	Molecular weight (g/mol)	Melting temperature (°C)	Crystallization temperature (°C)
N1		384	235	226
N2		328	243	219
N3		408	268	244
N4		396	279	256
N5		436	264	240
N6		436	239	222
N7		442	366	358
N8		437	150	145

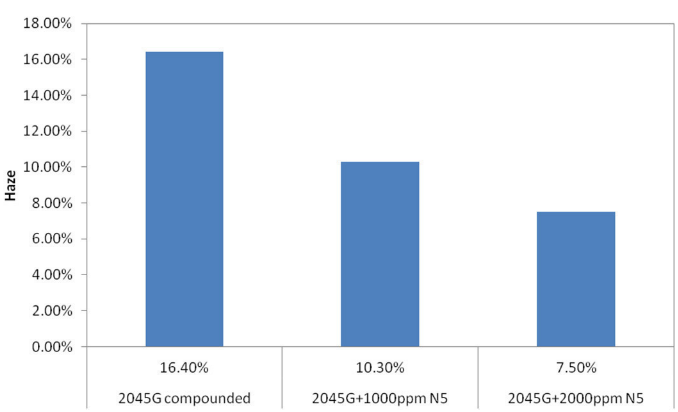


Figure 2. *Measured haze of 50μm-thick LLDPE (DOWLEX 2045G) blown films containing bis-oxalamide compound N5 at a concentration of 0, 1000, and 2000 parts per million (ppm).*

a 37 and 54% reduction in haze for the 1000 and 2000ppm samples, respectively. These results thus confirm the clarifying efficacy of N5 under industrially relevant processing conditions.

In summary, we have investigated the effect of *bis*-oxalamide compounds on the clarification of LLDPE (DOWLEX 2045G) for the first time. Our results, for a series of compounds that contain different core and pendant functional groups, show that the overall haze of the LLDPE could be reduced by up to 50% (with the addition of 0.2wt% of a particular compound). For most of the compounds we studied, we found that there was an optimal concentration that gave the lowest haze. This arises because of the solubility limitation of the clarifying agent in the bulk resin under the processing conditions. We note that there are many other factors that can affect macroscopic clarification performance and we hope to continue our investigations along those lines of enquiry.

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