Electronic Supplementary Material (ESI) for Polymer Chemistry.

Polymer composites with high haze and high transmittance

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1. Materials, methods and Instrument

Materials:

α-Methyl styrene (AMS, 99%) and Divinylbenzene (DVB, 80%) were purchased from Alfa Aesar. Maleic anhydride (MAH, AR) was supplied by Sinopharm Chemical Reagent Co., Ltd. All monomers were used as purchased without further purification, unless otherwise stated. Azodiisobutyronitrile (AIBN) was purified by a routine recrystallization from ethanol. Isopentyl acetate (AR) was analytical grade and used as received. Polycarbonate, ET3113, was purchased from Bayer Co. Silicone resin, 30-424, was purchased from Dow corning Co. Antioxidant 168 was purchased from BASF.

Experimental method

Synthesis：MAH (83.40 g), AMS (100.35 g), DVB (25.50 g) and AIBN (0.4935 g) were dissolved in 589.50 g of insolently acetate in a 1000 mL flask. After purging with N_2 for 20 min, the reactor was placed in an oil bath at 70℃. The polymerization was conducted for 6h without agitation. Then, crosslinked microspheres were separated by centrifugation and thoroughly washed with methanol to eliminate the monomer and initiator residues. The products were dried under vacuum at 50℃ overnight. Non-crosslinked microspheres were prepared without the addition of DVB (the formulation of other reagents kept unchanged) by following the same procedure described above.

Melting blending: PC was dried at 120℃ for 8h before being used and then blended with antioxidant, CM-SMC and/or silicone resin in a HAAKE Rheomex OS PTW 16 twin screw extruder. The barrel temperature was set at 240℃, 255℃, 265℃, 275℃, 270℃ from zone 1 to 5 and die temperature was set at 250℃.

Injection molding: The PC composites were dried at 120℃ for 8h before being used, and then injected into a wafer with 2-mm thick. The nozzle temperature was 290℃ and the mold temperature was 80℃.

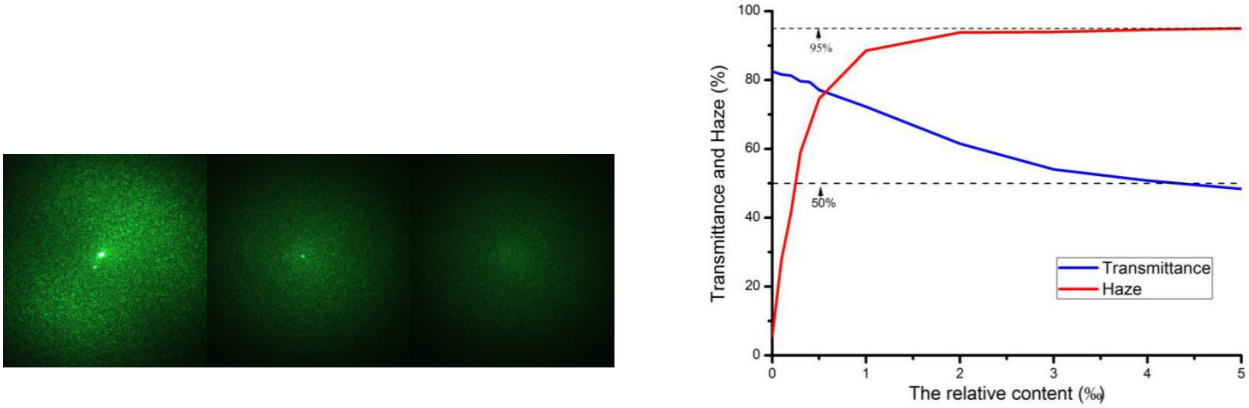
Light intensity, light intensity distribution spectra and light color temperature were tested in Chinese Academy of Metrology.

Instrument

PC composites were prepared by Thermofisher HAAKE Rheomex OS PTW 16 PolyLab Twin-Screw Extruder. Composite samples were molded by HaiTian HTF110X/1J injection molding machine. Transmittance spectra, Reflectance spectra, diffuse transmittance spectra and absorption spectra were tested on a SHIMADZU UV3600 UV visible spectrophotometer. Hazes were measured on a WGT-S transmittance and haze test measuring instrument. The morphologies of microsphere and PC surface were analyzed with a Hitachi S-4800 scanning electron microscope and AFM images were taken by using a Digital Instruments Nanoscope IIIa AFM. The Fluorescence spectra were measured on Edinburgh FLS980 fluorescence spectrometer. Photos of the scattering effect were taken from an Ultramicro CLY small angel light scattering instrument. PHILIPS recessed spot luminaire, model :66661, rated voltage: 220~240V(Rated). PHILIPS LED bulb, 5W, 3000k, 300ml, 35mA.

2. Light scattering properties

Silicon resin microsphere of Dow Corning 30-434(DC) is one of the most popular light-scattering agents in current market. It has been found that 0.5 wt% DC in PC/DC light-scattering materials is necessary as the product specification indicated because only when 0.5 wt% DC was used, the haze of the composite can reach to close 95% and spot lamp-house cannot be seen, as shown in Figure S1. At the same time, however, the transmittance of this composite had been reduced to 49% (Figure S1B), which means more than half energy of LED would be lost. When 1 wt% 800-nm CM-SMC and 0.3 wt% DC, instead of 0.5 wt% DC, were used to modify PC, a high performance light-scattering PC composite with haze of 96% and transmittance of 60% was prepared. That is to say, the new light-scattering material can save 20% energy compared to the PC composite with only 0.5 wt% DC. Besides, the preparation process for CM-SMC is a low cost and low energy consumption process; therefore, the new light-scattering material is an ideal material for energy saving and greenhouse gas emission reducing.



(A) (B)

Figure S1. (A) Light scattering effect of PC composites with different content of DC. (B) Transmittance and Haze of PC composites with different content of DC.

3. Molecule structure of Yan's polymer

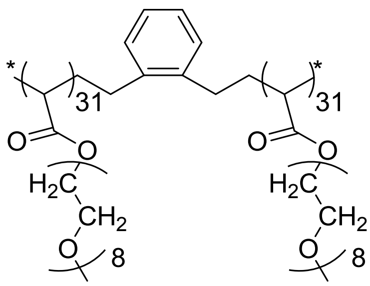


Figure S2. Molecule structure of Yan's polymer [1].

4. The light intensity distribution spectra, the luminous flux and the light color temperature

Figure S3 shows the LED device and Phillips lamp (A), light scattering effect of our PC composite (B), and Light intensity and light intensity distribution of LED device with and without our PC composite(C). Table S1 shows the color temperature of LED device with and without our PC composite. Table S2 shows the luminous flux of LED device with and without our PC composite. It can be found that the LED chips cannot be observed after being covered with our PC composite and the light color does not change; the color temperature of LED bulb with our PC composite doesn't change obviously; the angular distributions of the transmission increased from 60° to 90° and the sharp peaks of light intensity were disappeared after covering our PC composite. The luminous flux of LED bulb covered by our PC composite decreased from 242.30 to 145.77, more than 60% luminous flux is kept, which is as same as the total transmittance' result.

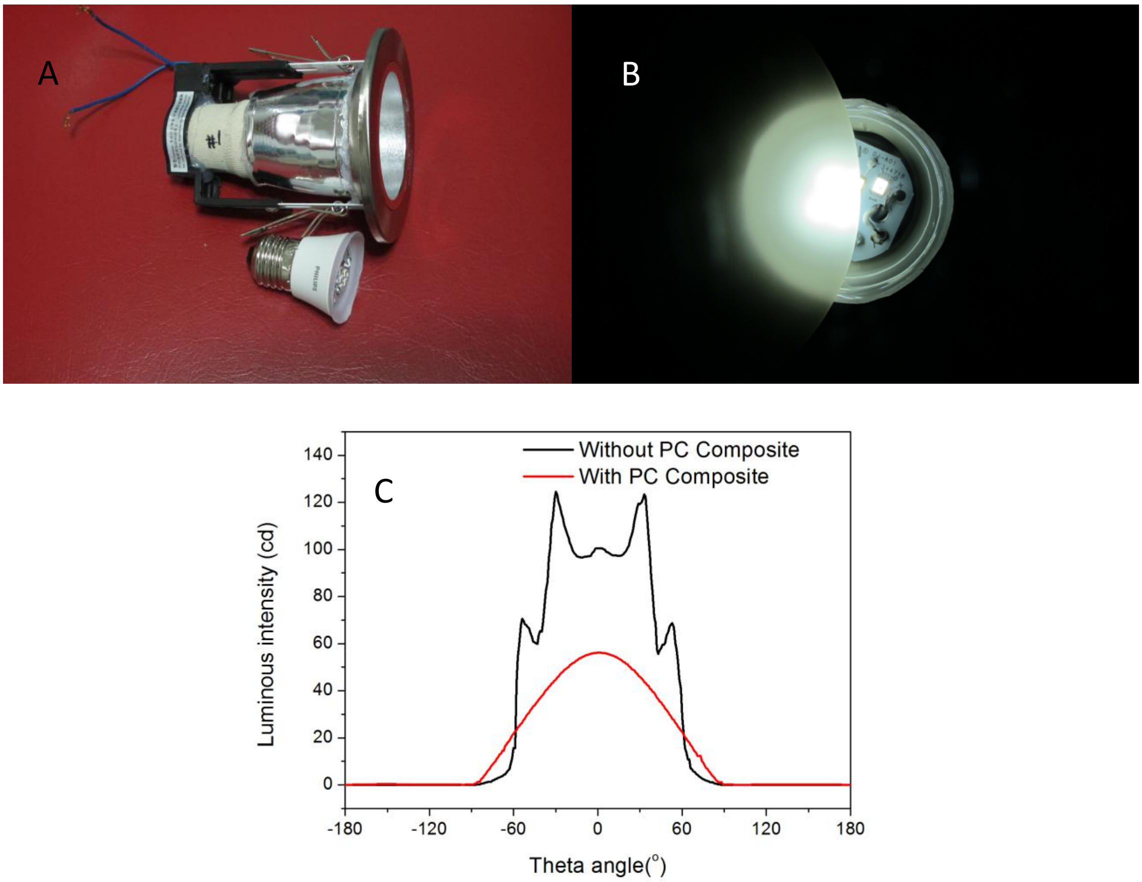


Figure S3 A ,The picture of LED device with Phillips lamp; B, the picture of light scattering effect of PC composite; C, Light intensity and light intensity distribution of LED device

Table S1 The color temperature of LED device

Samples	Label X	Label Y	Color temperature (k)
LED bulb without PC composite	0.4288	0.3941	3059
LED bulb with PC composite	0.4446	0.4049	2882

Table S2 The luminous flux of LED device

Samples	Voltage (V)	Electric current(mA)	Power (W)	Luminous flux (lm)
LED bulb without PC composite	220.0	30.55	3.304	242.30
LED bulb with PC composite	220.0	30.54	3.299	145.77

5. The total transmittance and the diffuse transmittance spectra

Table S3 The total transmittance of PC and PC composites

Samples	Pure PC	PC+0.3wt% DC	PC+0.5wt% DC	PC+1wt% 800CM-SMC	PC+0.3wt% DC+1wt% 800CM-SMC
Transmittance %	85.4	54.0	49.6	90.2	59.7
Haze %	0.63	93.9	94.9	18.6	96.3

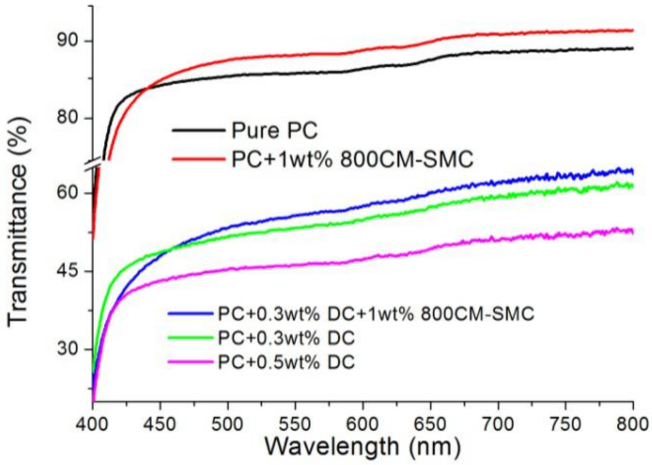


Figure S4 The diffuse transmittance spectra of PC and PC composites

References

1. J. J. Yan, Z. k. Wang, X. S. Lin, C. H. Hong, H. J. Liang, C. Y. Pan, Y. Z. You, Polymerizing nonfluorescent monomers without incorporating any fluorescent agent produce strong fluorescent polymers, Adv. Mater. 24, 5617–5624(2012)