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ARTICLE

A new approach to construct segregated structure in thermoplastic polyolefin elastomer towards improved conductive and mechanical properties

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Aiming at improved electrical conductive performance and simultaneously enhanced mechanical properties, a novel segregated structure was constructed for poly (ethylene-co-octene) (POE)/multi-walled carbon nanotube (MWCNT) elastomeric conductive composites with chemically cross-linked POE granules. Structural examination revealed the formation of unique phase morphologies with a stable segregated structure, in which the uncross-linked POE/MWCNT phase localized out of the cross-linked granules. With such a novel segregated structure, a percolation threshold as low as 1.5 vol. % of MWCNT was observed, which is significantly lower than the melt compounded POE/MWCNT composites; the stress at 100% and 300% stretching increased for more than 12% and 30%, respectively, and the tensile modulus inherent to the matrix elastomer was maintained. The elastic recovery of the composite with such a novel segregated structure was more than 85% and 65% after large strains up to 100% and 300%, respectively, always higher than the melt compounded POE/MWCNT composites. Shore A hardness of the elastomeric conductive composites with cross-linked POE granules was also lower, showing better elasticity of POE/MWCNT composites with such a novel segregated structure. All these results demonstrated that the elastomeric POE/MWCNT conductive composites with such a novel segregated structure exhibited greatly reduced percolation threshold with enhancement in mechanical properties, which provides a new way for the preparation of elastomeric conductive composites with simultaneously improved electrical performance and mechanical properties.

Introduction

Elastomeric conductive composites have received increasing attention recently due to persistent conductive pathways when stretched, bended, twisted or folded,¹⁻⁴ which provides great potential in the field of sensors, stretchable electronics, conductive adhesives, etc.⁵⁻⁸ The fabrication of elastomeric conductive composites can be realized from several strategies. One main strategy is to integrate conductive components such as carbon black,⁹ carbon nanotube^{10, 11} or graphene^{12, 13} within an elastomer matrix. There are two major challenges in the fabrication

of conductive elastomeric composites: reducing the content of conductive filler without decreasing the conductivity, i.e. lowering down the percolation threshold, and maintaining or even improving the mechanical properties of elastomer matrix.

Poly (ethylene-co-octene) (POE) is a new type of thermoplastic elastomers with different content of octene.¹⁴ POE possesses good thermal stability and fine ultraviolet resistance due to its saturated molecular chain structure. POE provides better processability than traditional rubbers, better impact resistance and lower cost than ethylene-propylene-diene monomer (EPDM),¹⁵ so POE can be

considered as a potential matrix for conductive elastomeric composites. As excellent conductive fillers, the high aspect ratio and strong π - π interactions of multi-walled carbon nanotube (MWCNT), single-walled carbon nanotube (SWCNT) and graphene make them difficult to be dispersed uniformly in polymer matrices, especially in melt compounding operations¹⁶ or in non-polar polyolefin matrices¹⁷. Also, the presence of comonomer in the main chain decreases the crystallinity of POE significantly,¹⁸ which results in increased percolation threshold of amorphous elastomer/carbon filler composites, especially when compared with crystalline polymer.^{19, 20} So in this work we choose MWCNT with relatively low aspect ratio as filler to prevent serious aggregation in amorphous elastomer matrix. The percolation threshold for POE/MWCNT composite is typically in the range of 12-14 wt. %, ²¹ which severely limit their practical applications in areas requiring high conductivity and balanced mechanical properties. Osazuwa et al.¹⁶ reported that electrical percolation threshold of low-viscosity POE/MWCNT composites were observed at a filler loading of about 1 wt. % by functionalizing MWCNT with hyperbranched polyethylene, but the functionalization of MWCNT was complex and is difficult for wide industrial production. Therefore, a high-efficient, cost effective approach is required for broader industrial applications of conductive elastomeric composites.

In order to lower down the percolation threshold of polymer composites as much as possible, many methods have been reported. Numerous conductive composites with lower electrical percolation threshold values were fabricated based on double percolation,²²⁻²⁵ the location of fillers at phase interface,²⁶⁻²⁸ or the construction of segregated structures in conductive composites.^{29, 30} Among those methods, constructing segregated structure in conductive polymer composites has caught great attention and has been considered as the most effective approaches.²⁹⁻³² Usually, high-melt-viscosity polymers such as ultrahigh molecular weight polyethylene,^{33, 34} poly(vinylidene fluoride),³⁵⁻³⁷ polystyrene^{38, 39} and natural rubber (NR)^{12, 30, 40} are utilized to construct segregated structures. Conductive fillers based conductive channels of these composites are segregated in the perimeters of polymeric granules other than distributed throughout the

entire composites randomly. Those segregated granules are allotted a constrained volume, leading to denser effective concentration of conductive pathways and better contact between conductive fillers to form conductive network at a certain filler loading, thus a low percolation threshold can be achieved. For example, Mamunya et al.^{41, 42} and Grunlan et al.⁴³ demonstrated that the segregated structures in polyvinyl chloride /MWCNT composites and poly(vinyl acetate) /SWCNT composites led to ultra-low percolation thresholds. Unfortunately, due to the weak interfacial interactions or the presence of defects between those segregated granules or conductive fillers and polymer matrix, the majority of conductive polymer composites with segregated structures always exhibit inferior mechanical properties. For instance, Potts et al.^{12, 13} reported that the elongation of NR/reduced graphene oxide composites decrease up to 90%. Herein a novel method to reduce the percolation threshold without severe damage in the mechanical performance of conductive polymer composites is urgently needed, especially for conductive elastomeric composites.

Here, a segregated structure was constructed with cross-linked granules in POE/MWCNT composite. Our previous work reported that the conductive fillers dispersed selectively outside cured EPDM particles caused by the high viscosity of cured EPDM compared with PP matrix.⁹ Thus in this work, MWCNT are deemed to primarily locate outside cross-linked POE granules due to its high viscosity compared with that of POE matrix. Besides, due to the size disparity between MWCNT and the cross-linked granules, a stable segregated structure is constructed by cross-linked granules and the percolation threshold of the composites can be reduced greatly. At the same time, the cross-linked granules are prepared by chemical cross-linking of POE, the same material as the matrix. Therefore excellent interfacial adherence of the matrix to segregated granules can be expected due to the utilization of the same polymer, and then the damage to mechanical properties of the composites will be greatly restrained. The electrical performance, mechanical properties (esp. stress at certain stretching, tensile modulus), elastic properties and hardness of POE/MWCNT composites with the designed segregated structure were investigated. The resulted conductive

elastomeric composites exhibited greatly reduced percolation threshold, improved mechanical properties, enhanced elasticity and lower hardness, which demonstrates that this simple and high-efficient new approach is highly probable to find wide applications in the fabrication of conductive elastomers with improved comprehensive performance.

Experimental section

Materials

POE (ENGAGE 8150) with a melt flow rate of 0.5 g/10 min, was purchased from Dow Chemical Co. (Midland, MI, USA). MWCNT (XFM13), with an average diameter of 10-20 nm and a length of 10-30 μm , was purchased from XFNANO Inc. (Nanjing, China). Dicumyl peroxide (DCP, AR) was purchased from Best-Reagent Co. (Chengdu, China) and was used as-received without any further treatment.

Sample preparation

To prepare cross-linked POE particles for the construction of segregated structure, static vulcanization of POE with 3 phr (to the weight of POE before cross-linking) DCP (with relatively high reactivity and efficiency in peroxides used to cross-linking POE⁴⁴), was carried out first in a press vulcanizer at 170°C under 10 MPa for 15 min. The resulted cross-linked POE sheet with a thickness of about 1.2 mm was pulverized by high-speed mechanical pulverizer at a speed of 25000 rpm for 3 min, and then meshed with a screening sifter. The pulverized particles between 40 meshes and 60 meshes (250 ~ 380 μm) were utilized as the cross-linked POE granules to construct the segregated structure.

All the cross-linked granules/POE/MWCNT composites were prepared in an internal mixer (XSS-300, Shanghai Kechuang Rubber Plastics Machinery Set Ltd, China) at 50 rpm and 150 °C. The composites with the designed segregated structure were melt compounded with two steps. First, POE and MWCNT were melt compounded for 5min to prepare POE/MWCNT master batch; then the cross-linked POE granules were added in and the mixture was continued to compound for another

5min. The mass fraction of the cross-linked granules was maintained to be 75 %. Resulted samples were marked as cross-linked granules/POE/MWCNT-x, where cross-linked granules/POE/MWCNT represents the composites with segregated structure and x stands for the volume fraction of MWCNT content in the composites. For comparison, conventional POE/MWCNT composites without cross-linked granules were also prepared by melt compounding POE/MWCNT master batch in the same internal mixer at 50 rpm and 150 °C for another 5 min. These samples were named as POE/MWCNT-x, where POE/MWCNT represents the composites without cross-linked granules and x stands for the volume fraction of MWCNT content in the composites.

The preparation of the cross-linked granules, conventional POE/MWCNT composites, and cross-linked granules/POE/MWCNT composites, is intuitively and schematically illustrated in Fig. 1. After compounding, all the composites were compression molded into sheets with a thickness of about 1.2 mm at 150 °C for 10 min under a pressure of 10 MPa.

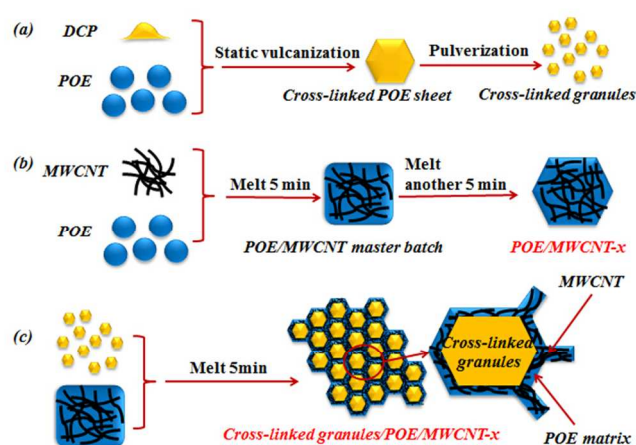


Fig. 1 Schematic representation for the preparation of (a) cross-linked granules, (b) POE/MWCNT composites and (c) cross-linked granules/POE/MWCNT composites.

Characterization

Volume swelling ratio measurement

The volume swelling ratio (Q) of the cross-linked POE sheet was tested as a measure of the cross-linking degree

of POE in cross-linked granules, by extraction in cyclohexane at 25°C. For the swelling test, rectangular test sample with a dimension of 16 mm × 14 mm × 1.2 mm was immersed in cyclohexane for 72 h under 25°C; the solvent was refreshed every 24 h to remove extracted components. The swelling mass (m_s) and the residual mass (m_d) of the sample was determined before and after drying the swelling sample in a vacuum oven at 60 °C for 72 h, respectively. The volume swelling ratios (Q) of the sample was calculated by using Equation (1) and (2)⁴⁵:

$$\phi_p = \frac{v_p}{v_s} = \frac{1}{1 + \frac{m_s - m_d}{m_d} \times \frac{\rho_p}{\rho_s}} \quad (1)$$

$$Q = \frac{v_s}{v_p} \quad (2)$$

where ϕ_p is the volume fraction of polymer in the whole sample after swelling; v_p and v_s are the volume of sample before and after swelling, respectively; ρ_p and ρ_s are the density of the sample and the solvent (cyclohexane) respectively. With the values of m_s , m_d , ρ_p and ρ_s , the values of Q can be obtained. Here, ρ_s is provided by the manufacturer, which is 0.779 g/cm³.

Morphological observation

Phase morphologies of the composites and the distribution of MWCNT were characterized with a JEOL JSM-5900LV scanning electron microscope (SEM, Japan) at an accelerating voltage of 20 kV. The compression molded sheets of the composites were immersed in liquid nitrogen for 30 min, and then quickly impact fractured. The sample for the observation of segregated structure was etched in cyclohexane for 2h at 15 °C. The tensile fracture surface was acquired directly from tensile fracture testing. All the fresh surfaces were sputter coated with gold prior to examination. Transmission electron microscopy (TEM, Philips CM120) was used to characterize the interface between cross-linked granules and POE matrix in cross-linked granules/POE/MWCNT composites. Before observation, the samples were cryomicrotomed into 50~100-nm-thick sections at -120 °C.

Electrical conductivity

For the characterization of room-temperature volume resistivity, the composites were cut into rectangular sheets with a dimension of 1.2 mm × 10 mm × 30 mm (both sides of the samples were coated with silver paste to reduce the contact resistance) and 1.2 mm × 200 mm × 200 mm, respectively; then the volume resistivity of the samples were measured consecutively by employing a digital multimeter (6517B, Keithley Instruments, Inc, Ohio, USA) (below 10⁶ Ω) and a high-resistivity meter (ZC36, Shanghai Precision Instruments Co., Ltd. China) (above 10⁶ Ω), respectively. At least ten samples were tested for each measurement and the average results were reported.

Mechanical properties

The mechanical performance testing was performed on an AGS-J universal material testing machine (the maximum capacity of the load cell was limited to 10 kN) at room temperature with a gauge length of 10 mm. All samples used for mechanical performance testing were dumb-bell samples with a dimension of 10 mm × 2 mm × 1.2 mm. The tensile fracture test was carried out at a crosshead speed of 100 mm/min. At least five samples were tested and the average results were reported. The tensile extension-relaxation measurements were conducted according to Svoboda et al.¹⁵ and Seyedin et al.⁴⁶, and the tensile extension-relaxation curves were measured at a crosshead speed of 10 mm/min. After the pre-set strain (100% and 300%) was attained, the crosshead returned at the same speed. At least five samples were repeated and the average results were reported. Shore A hardness was measured using an indentation hardness tester according to ASTM D2240-75.

Results and discussion

Cross-linking degree of the cross-linked POE

The sample of virgin POE for volume swelling ratio measurement was dissolved absolutely in cyclohexane after 72 h, so the volume swelling ratios (Q) of it cannot be measured. The density of the cross-linked sample (ρ_p) was measured to be 0.855g/cm³, and Q of cross-linked sample can be calculated to be 5.622. According to Vennemann et al.⁴⁵, higher volume swelling ratio represents lower cross-linking degree of the cross-linked samples. Here, the Q

value of the cross-linked POE is relatively high, demonstrating that the cross-linking degree of the cross-linked POE granules is relatively low but is effective.

Phase morphologies

To clearly manifest the constructed segregated structure, we chose the composite without loading MWCNT to observe the segregated structure of cross-linked granules/POE/MWCNT composite by SEM. Then we chose the composite with relative high loading content of MWCNT (i.e. cross-linked granules/POE/MWCNT-1.8) to characterize the distribution of MWCNT, and the representative results are shown in Fig. 2.

The polygons in the etched samples in Fig. 2a and c were un-dissolved and discontinuous, showing that they were cross-linked granules. Therefore, the polygons in Fig. 2b and d without any MWCNT are also cross-linked

granules. Some small cross-linked POE granules with dimensions smaller than 100 μm were formed under the intense shear during melt compounding. It is clear that a typical segregated structure is successfully constructed in the cross-linked granules/POE/MWCNT composites as shown in Fig. 2a and b, and the cross-linked granules distributed uniformly in the POE matrix. As expected, MWCNT in cross-linked granules/POE/MWCNT composites were selectively distributed only in POE matrix, as seen in Fig. 2b, d and f, and no migration of MWCNT occurred during sample preparation, showing a stable and excellent volume exclusion effect of cross-linked granules. In addition, we cannot see any crack or defect at the interface between granules and matrix as shown in Fig. 2e and f, clearly showing the excellent interfacial adherence of POE molecular chains towards its homogeneous cross-linked granules.

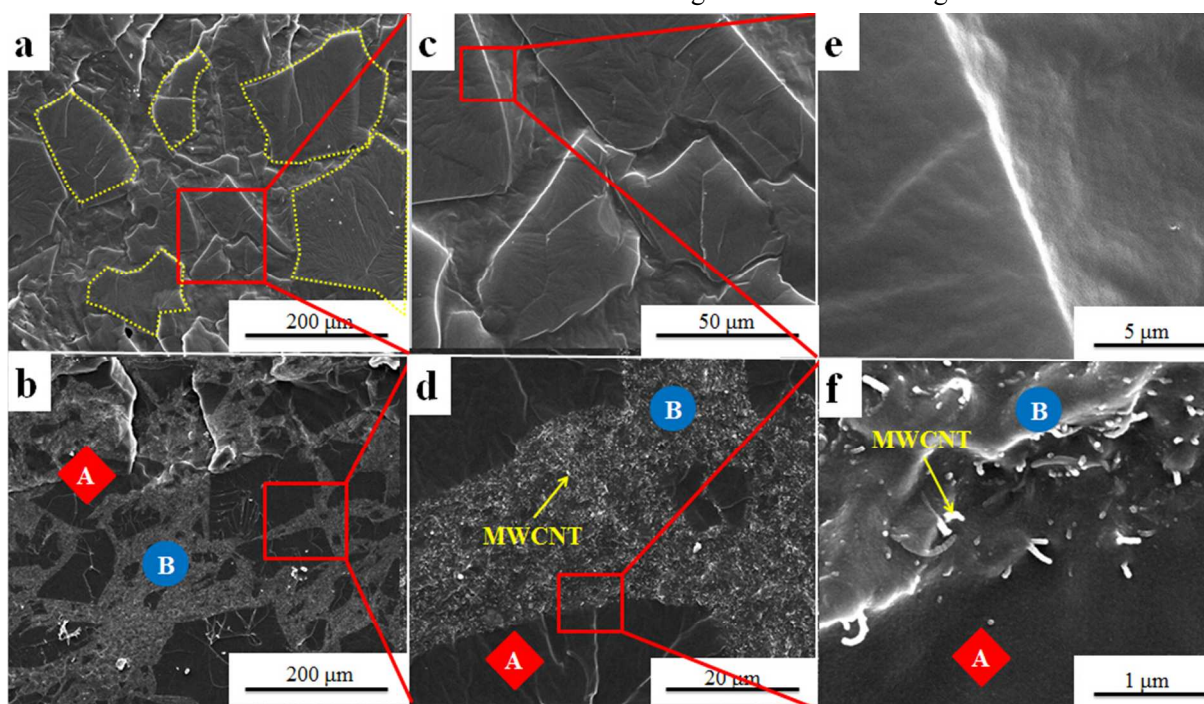


Fig. 2 Typical SEM images of (a) etched cross-linked granules/POE/MWCNT-0, (b) cross-linked granules/POE/MWCNT-1.8; (c), (e) and (d), (f) are the amplification of (a) and (b) respectively. Yellow circles show the perimeters of several cross-linked granules, Region A represents cross-linked granules and Region B corresponds to POE phase containing MWCNT.

To directly show the interface between cross-linked granules and POE matrix, TEM images were taken and shown in Fig. 3. The dark bundles in Fig. 3a, b and c

represent MWCNT dispersed in POE phase and the other phase without any dark MWCNT bundle corresponds to cross-linked POE granules. It is clear that MWCNT were

segregated in the perimeters of cross-linked granules in accordance with SEM results. More importantly, no interfacial flaws can be observed and the contour of cross-linked POE granules cannot be clearly distinguished from the matrix along the interface as seen in Fig. 3c, and this is also confirmed with peeling tests shown in Fig. S1 in the Supporting Information, as quite good peeling strength is

maintained for the POE-cross-linked POE sample, suggesting that the cross-linked granules were coherently combined with the matrix, and excellent interfacial adhesion formed between the cross-linked POE granules and the POE matrix, which can be ascribed to the strong adherence of matrix to cross-linked granules (of the same chemical composition) at the interface.

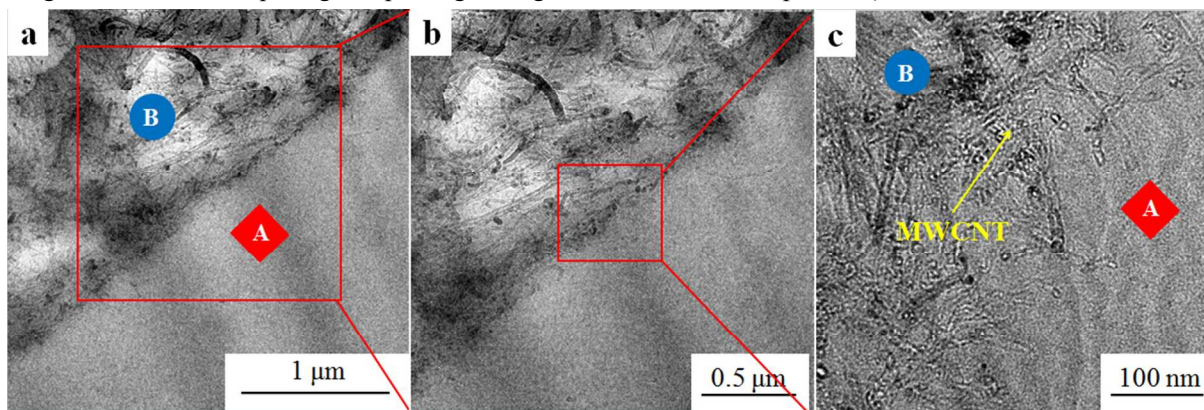


Fig. 3 (a) Typical TEM images of cross-linked granules/POE/MWCNT-3.7; both (b) and (c) are the amplification of (a). Region A represents the cross-linked granules and Region B shows POE phase containing MWCNT.

Electrical properties

As a conductive elastomeric composite, one of the most important challenges is to reduce the percolation threshold.

Fig. 4 shows the electrical conductivity of all the composites as a function of MWCNT content. The electrical conductivity of the composites increase rapidly with increasing filler content around a certain content,

showing the typical percolation behaviour. As can be seen in Fig. 4a, the conductive performance of cross-linked granules/POE/MWCNT composites is much better than that of conventional composites without segregated structure (POE/MWCNT composites) at the same content of MWCNT.

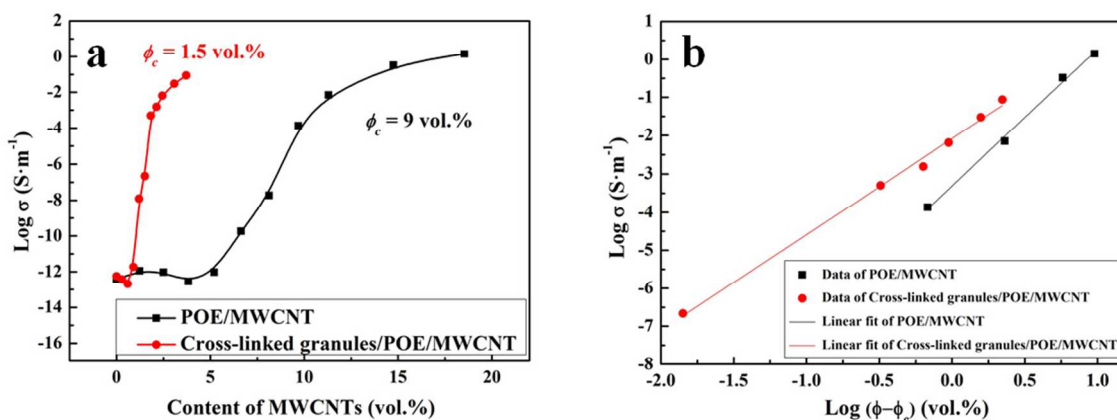


Fig. 4 (a) Electrical conductivity as a function of MWCNT content and (b) the fitted results of experimental data of cross-linked granules/POE/MWCNT composites and POE/MWCNT composites according to percolation law.

Usually the electrically conductive behaviour of a conductive polymer composite can be described using the power law shown in Equation (3),

$$\sigma = \sigma(\phi - \phi_c)^t \quad (3)$$

where σ is the electrical conductivity of conductive polymer composite, ϕ is the content of MWCNT, ϕ_c is the threshold of the electrical conductivity percolation, and t is the critical exponent.⁴⁷⁻⁵⁰ As shown in Fig. 4, the percolation threshold of the cross-linked granules/POE/MWCNT composites is only 1.5 vol. %, far lower than that of conventional POE/MWCNT composites, which is as high as 9 vol. %. As is known to all, the electrical properties of composites are related closely with the distribution of conductive fillers in the matrix.^{51, 52} Due to the segregated structure constructed with cross-linked granules as displayed in Fig. 2 and 3, the effective concentration of conductive MWCNT pathways to form the conductive network is denser, and the contact between MWCNTs become better as mentioned above, thus the percolation threshold of cross-linked granules/POE/MWCNT composites is significantly decreased and the conductivity is greatly improved.

Mechanical Properties

Previous literatures reported that the weak interfacial interactions between segregated structure or conductive fillers and polymer matrix always led to inferior mechanical properties of composites.^{12, 30} For practical applications, the mechanical properties of materials should also be paid attention to. In other words, whether the mechanical properties of the composites with such a segregated structure can be maintained or even enhanced due to the excellent interfacial adherence of POE with cross-linked granules is required to be investigated.

Apart from the interfacial interactions between segregated structure and the matrix, the content of MWCNT influences the mechanical performance of composites significantly. Therefore, we chose cross-linked POE, cross-linked granules/POE/MWCNT-0, 1.2, 2.4, 3.7 and POE/MWCNT-0, 1.2, 2.4, 3.7 with no, relative low or

high loading content of MWCNT, to characterize the mechanical properties.

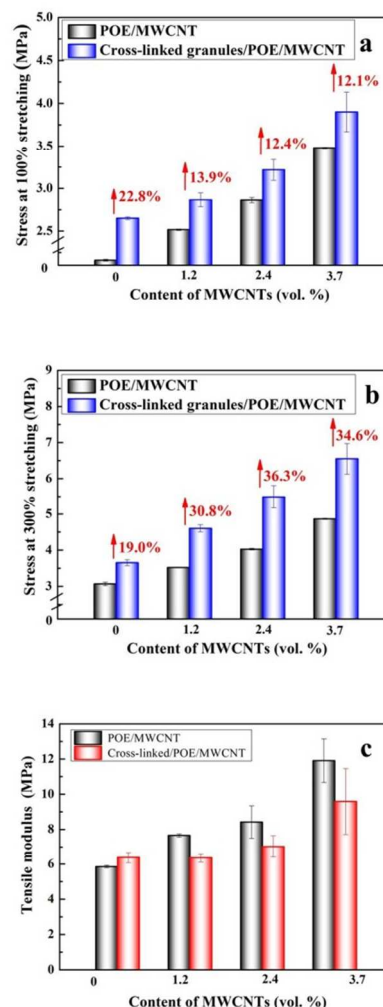


Fig. 5 (a) The stress at 100% stretching, (b) the stress at 300% stretching, and (c) the tensile modulus of POE/MWCNT composites and cross-linked granules/POE/MWCNT composites.

The representative uniaxial tensile stress-strain curves of the elastomeric composites in Fig. S2 in the Supporting Information resemble those of typical thermoplastic elastomers.^{46, 53} Fig. 5a and b shows the stress at 100% and 300% stretching of POE/MWCNT composites with and without segregated structure at different MWCNT loadings. As can be seen, after the incorporation of cross-linked granules, the stress at 100% and 300% stretching increased

for more than 12% and 30%, respectively, when compared with POE/MWCNT composites at the same content of MWCNT. Fig. 5c displays the tensile moduli of the composites. Tensile moduli of all composites are less than 12 MPa, indicating that all composites are still rubber-like material. The tensile modulus of cross-linked granules/POE/MWCNT always maintained the same level as traditional POE/MWCNT at the same content of MWCNT, showing maintained tensile flexibility of cross-linked granules/POE/MWCNT composites.

The enhancement in the tensile strength of cross-linked granules/POE/MWCNT composites may be attributed to the addition of the cross-linked granules, which is achieved as a result of the incorporation of more rigid reinforcing granules with the three-dimensional networks formed by chemical cross-linking point. The three-dimensional networks of cross-linked granules help in dissipating a large amount of energy through the interface, thus bringing better ability to bear loading, leading to better tensile strength. And the improvement of tensile strength also indicates the strong interfacial adherence of POE towards the homogeneous segregated granules.

In order to further investigate the relationship between structure and properties, SEM observation of tensile fractured surfaces of samples were used to study the details of the structure upon deformation. The tensile fractured surfaces of cross-linked granules/POE/MWCNT composites show not any structural defect or macro-crack at the interfaces between segregated structure and the matrix after tensile fracture as shown in Fig. 6c, suggesting that the interfacial adherence is favorable and shows a powerful adhesive effect, thus leading to improved tensile strength. Different from cross-linked granules/POE/MWCNT composites, POE/MWCNT composites show a ductile surface as shown in Fig. 6d, corresponding to the severe slippage between POE molecular chains in POE/MWCNT composites, indicated worse ability to bear loading without cross-linked granules.

To characterize the elasticity of the composites, we chose pre-programmed maximum strains of 100% and 300% to conduct tensile extension-relaxation measurements which were signed as Exp100 and Exp300, respectively. For brevity, we chose cross-linked granules/POE/MWCNT-0, 1.2, 2.4 and 3.7 and POE/MWCNT-0, 1.2, 2.4 and 3.7 to discuss. According to Seyedin et al.⁴⁶, the elasticity can be reflected by elastic recovery (marked as $ER_{\epsilon-100}$ and $ER_{\epsilon-300}$ for Exp100 and Exp300, respectively) calculated by Equation (4) after tensile extension-relaxation tests:

$$ER_{\epsilon} = \frac{\epsilon - \epsilon_R}{\epsilon} \times 100 \quad (4)$$

where ϵ is the applied strain, ϵ_R is the residual strain after extension-relaxation tests and is obtained directly from extension-relaxation curves and the representative curves were marked in Fig. S3 in the Supporting Information and the results are shown in Fig. 7a and b. The Shore A hardness of all POE/MWCNT and cross-linked granules/POE/MWCNT composites were also tested and the results can be seen in Fig. 7c.

From Fig. 7a and b, the total elastic recovery of cross-linked granules/POE/MWCNT composites are more than 85% and 65% after Exp100 and Exp300, respectively, showing excellent elasticity of composites with such a designed segregated structure. $ER_{\epsilon-100}$ and $ER_{\epsilon-300}$ of the composites with cross-linked granules are always

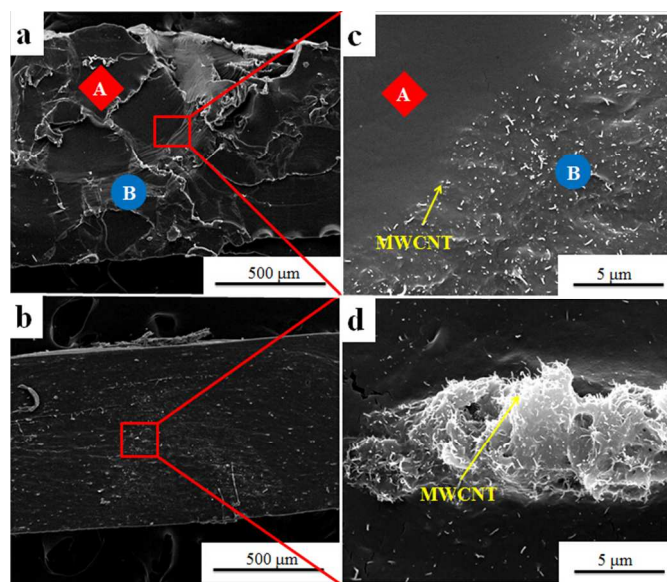


Fig. 6 Typical SEM images of tensile fracture surfaces of (a) cross-linked granules/POE/MWCNT-1.2 and (b) POE/MWCNT-1.2; (c) and (d) are the amplification of (a) and (b). Region A represents the cross-linked granules and Region B shows the POE phase containing MWCNT.

higher than traditional POE/MWCNT composites at the same content of MWCNT, suggesting better elasticity of the former composites.

Samples deform when stretched and the deformation after extension-relaxation test can be reflected by residual strain ϵ_R , and then the residual strain ϵ_R is translated to elastic recovery through Equation (4) to describe the elasticity of all the composites. According to Seyedin et al.⁴⁶, the ERe values were taken as the normalized difference between applied strain and permanent set. The permanent set is caused by slippages between molecular chains, so the results above indicated that the slippages between cross-linked POE molecular chains in cross-linked granules/POE/MWCNT composites were restricted, probably due to the cross-linking points of cross-linked granules and the excellent interfacial adherence of POE towards its homogeneous cross-linked granules, resulting in improved elasticity.

Besides, the fracture surfaces of cross-linked granules/POE/MWCNT-1.2 indicated lower plasticity of cross-linked granules/POE/MWCNT composites as observed from Fig. 6a and c, which is caused by the restricted molecular chains slippage induced by the cross-linking points and the excellent interfacial adhesion. For POE/MWCNT-1.2 in Fig. 6b and d, severe molecular chain slippage between POE chains under large tensile deformation can be observed and these results also suggest that the segregated structure can restrain slippages between POE molecular chains through the interface, leading to reduced permanent deformation and improved elasticity of conductive elastomer.

All Shore A hardness of composites were between 70 and 85 as in Fig. 7c, indicating that all the composites were still elastomeric. Due to the selectively distribution of MWCNT in cross-linked granules/POE/MWCNT composites as shown in Fig. 2 and 3, the negative effect of MWCNT on Shore A hardness was decreased so that Shore A hardness of cross-linked granules/POE/MWCNT composites are always lower than POE/MWCNT composites at the same content of MWCNT, showing better elasticity of cross-linked granules/POE/MWCNT composites.

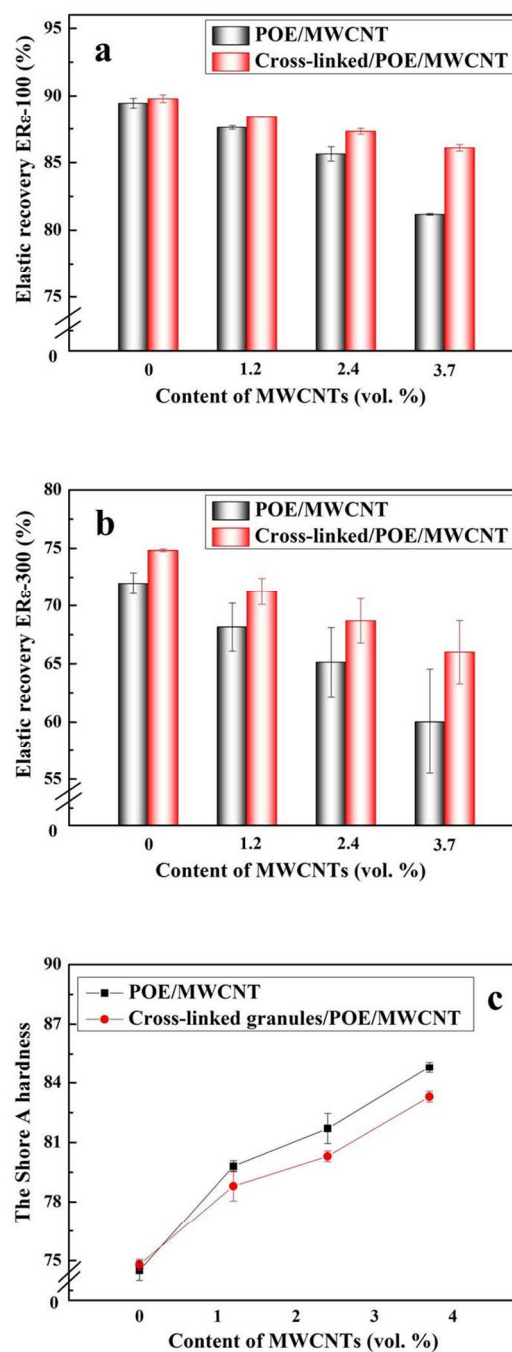


Fig. 7 (a) The elastic recovery after Exp100, (b) the elastic recovery after Exp300, and (c) Shore A hardness of cross-linked granules/POE/MWCNT and POE/MWCNT composites.

All in all, a combination of greatly reduced percolation threshold, improved mechanical performance and better elasticity of conductive elastomeric composites is achieved through constructing a segregated structure via incorporating cross-linked granules from the homogeneous polymer as the matrix, which provides a new design concept for conductive elastomeric composites and can also be applied in fabrication of conductive elastomeric composites based on NR, EPDM and other elastomers.

Conclusions

In summary, by constructing a segregated structure via incorporating cross-linked granules originated from the homogeneous polymer as the matrix, we presented a novel conductive elastomeric composite with greatly reduced percolation threshold, improved mechanical performance and elasticity, compared with neat POE/MWCNT composites. This method provides guidance for preparation of conductive elastomeric composites with improved mechanical performance, and potentially utilized widely in industrial application.

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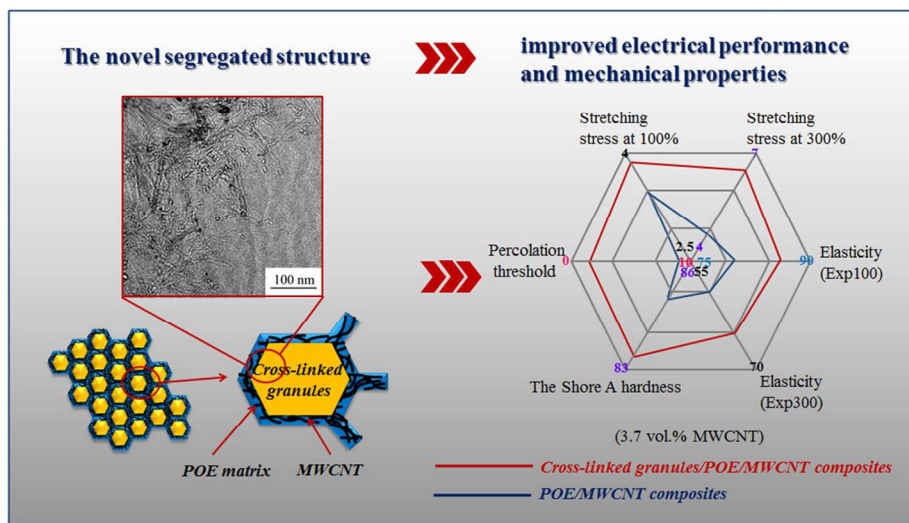
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Table of contents entry



A novel approach for the development of conductive elastomeric composites with improved electrical performance and mechanical properties is provided.