PAPER • OPEN ACCESS

Magnetic properties of TPU/NR blends: low loading NiZn and LNR added

To cite this article: Nor Azwin Ahad and Sahrim Hj Ahmad 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **701** 012017

IOP Conf. Series: Materials Science and Engineering **701** (2019) 012017 doi:10.1088/1757-899X/701/1/012017

Magnetic properties of TPU/NR blends: low loading NiZn and LNR added

Nor Azwin Ahad[1] *and Sahrim* Hj Ahmad[2]

[1]School of Materials Engineering, Kompleks Pusat Pengajian Jejawi 2, Universiti Malaysia Perlis 02600 Jejawi, Perlis, Malaysia.
[2]School of Applied Physic, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

Abstract. Thermoplastic polyurethane and natural rubber blending are able to change the origin properties polymer material. Then, this blend was added with magnetic filler, NiZn at low loading of 1wt% to 5wt%. Other than that, liquid natural rubber (LNR) was also added as compatibilizer. The previous study presented, NiZn ferrite at 3wt% in TPU/NR blend is the optimum filler loading, but LNR was not unbeaten in its role as compatibilizer. The addition of this magnetic filler enhanced the magnetic properties on saturation magnetization and remanence magnetization but decreased the value of coercive force.

1 Introduction

Modification in the behaviour and the improvement of the polymer properties has made it an ideal material for use in aerospace, transportation, packaging and food industries. The nature of the origin of the polymeric material is an electric resistor and nonmagnetic material. However, these properties may be changed by adding magnetic materials. For that purpose, NiZn were used in this study, which are blended together with TPU/NR. TPU are easily processing and make it possible to be blended with NR which provides low compounding temperature and good nature as polymeric material. Previous studies have been carried out, regarding TPU / NR formulations with NiZn and demonstrated on thermomechanical [1], DMA [2] and others. Besides, we studied also about tensile properties and swelling behaviour [3]. In this paper, we investigated the effect of adding low loading NiZn as filler and LNR as compatibilizer in the blends, to explore on their magnetic properties.

2 Methodology

Thermoplastic polyurethane (TPU) is a type of polyester-based 11T80 PEARLTHANE with A82 Shore hardness obtained from MERQUINSA Company. Natural rubber (NR) grade SMR-L with a density of 0.92g cm3 supplied by the Rubber Institute of Malaysia (RRIM). Liquid natural rubber (LNR) is available in research laboratories with natural rubber photo oxidation degradation method [3]. NiZn ferrite was used as filler supplied by Nanostructures & Amorphous Materials, Inc. USA, where its purity is 98.5% and particle size of 3 -10 nm.

IOP Conf. Series: Materials Science and Engineering **701** (2019) 012017 doi:10.1088/1757-899X/701/1/012017

As this study was carried out from the previous [1, 3], the samples were prepared by the optimal composition for TPU / NR and LNR i.e. 85TPU/15NR and 85TPU/5NR/10LNR [21], as well as a filler content of 1 to 5% by eight. The TPU/NR blends were prepared by melt blending technique using laboratory internal mixer (model RheoHaake 600p). Blending was carried out at temperature 180°C, with a mixing speed of 60rpm for 10 min and then pressed at 185°C under 45MPa of pressure for about 2 min using hot press (Carver Laboratory Press) into thin sheets.

The magnetic properties were measured using vibrating sample magnetometer (VSM model LDJ 9600) at room temperature. The measurements were carried out in a maximum field of 12kOe. Magnetic parameters such as

saturation magnetization (Ms), remanence (Mr) and coercivity (Hc) were determined.

3 Results and Discussion

The investigation of the magnetic properties of a material is important to understand the usefulness of the material. The sample is tested to reach a saturation state in which the material becomes a single domain in that state. The magnetic properties of TPU / NR and TPU / NR / LNR composites containing NiZn ferrite are explained using magnetic hysteresis loops versus magnetic fields. Fig. 1and Fig. 2 shows a hysteresis loop for magnetizing against the maximum magnetic field, which is applied in the magnetic field range of -12 kOe to 12 kOe at room temperature. Practically, all the samples have the same form of hysterisis loop. So, it can be concluded that the composite is soft magnetic at room temperature, due to the resulting hysterisis loop being narrow with little coercive force. Saturation magnetization (Ms), remenance magnetization (Mr), saturated magnetic field and coercive force (Hc) are magnetic properties parameters that can be obtained from magnetic hysterisis loop.

For all the samples, it was showed that the alignment of the magnet moment increases with an increase in the magnetic field. The magnetic moments in the sample align with the direction of the applied magnet field. The magnetization increases rapidly in a low magnetic field region before reaching a constant value held by the magnetizing magnet (Ms). When the magnetic field is amplified, Ms is found to increase with an increase in the filler in the matrix. Composite samples tend to follow the nature of ferrite if the filler content increases, because the magnetic nature of the filler will influence the composites.

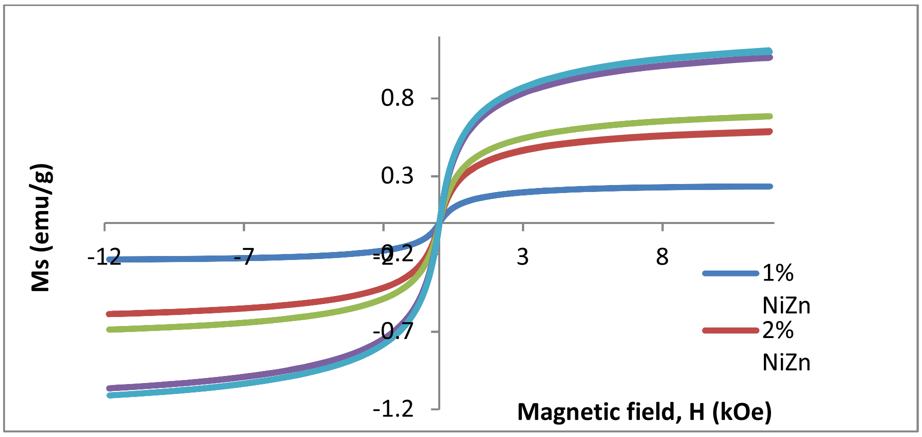

Fig. 1 The room temperature magnetization curves of TPU/NR blends.

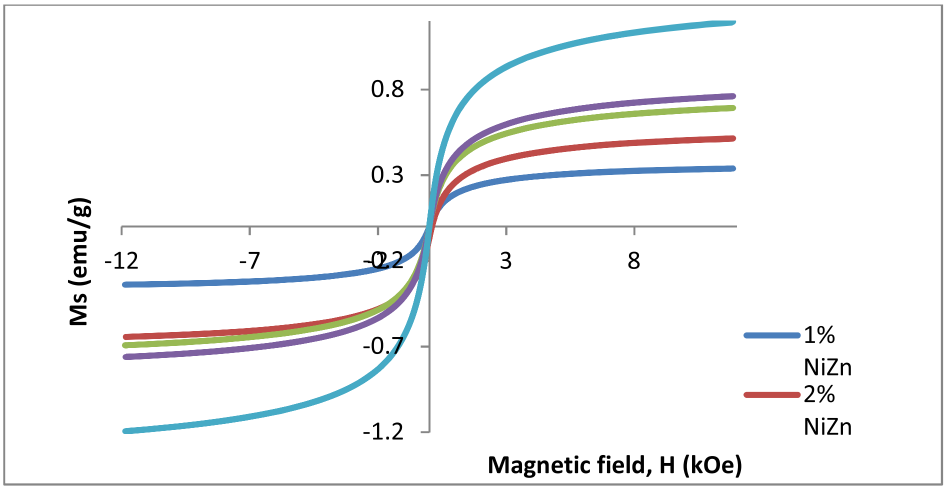

Fig. 2 The room temperature magnetization curves of TPU/NR/LNR blends.

Saturation magnetization (Mr) refers to magnetizing that remains in the magnetic material when the magnetic field is removed. It is a measure of the degree of magnetic resistance for a material, where saturation magnetization is the magnetic direction remaining in the magnetic material when the external magnetic field is removed. Increased saturation magnetization is characterized as a change in interaction between particles. The value of Ms and Mr for polymer magnetic composites increased with an increase in the magnetic powder loading in the polymer [4, 5]. The proportion of TPU / NR and TPU / NR / LNR composites increases linearly with the increase in Ms as shown in Fig. 3 and Fig. 4.

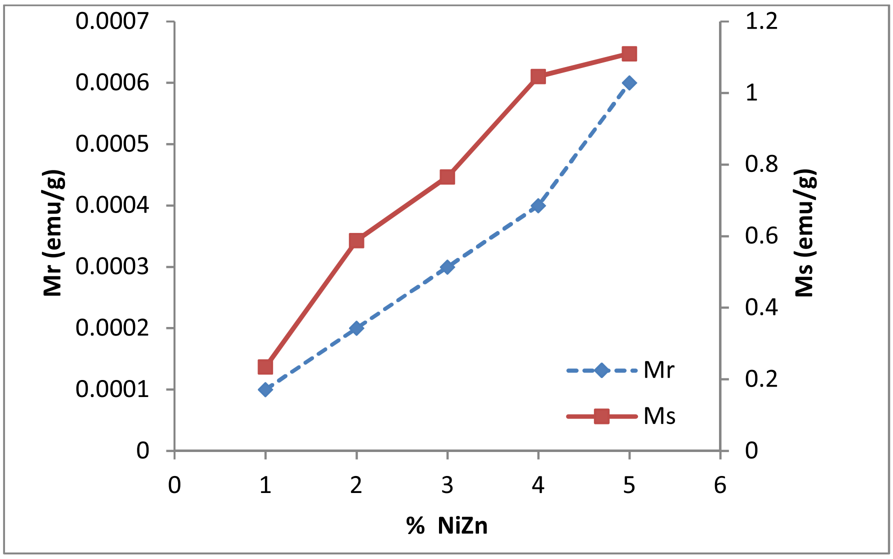

Fig. **3** Saturation magnetization and remenance magnetization of TPU/NR blends.

IOP Conf. Series: Materials Science and Engineering **701** (2019) 012017 doi:10.1088/1757-899X/701/1/012017

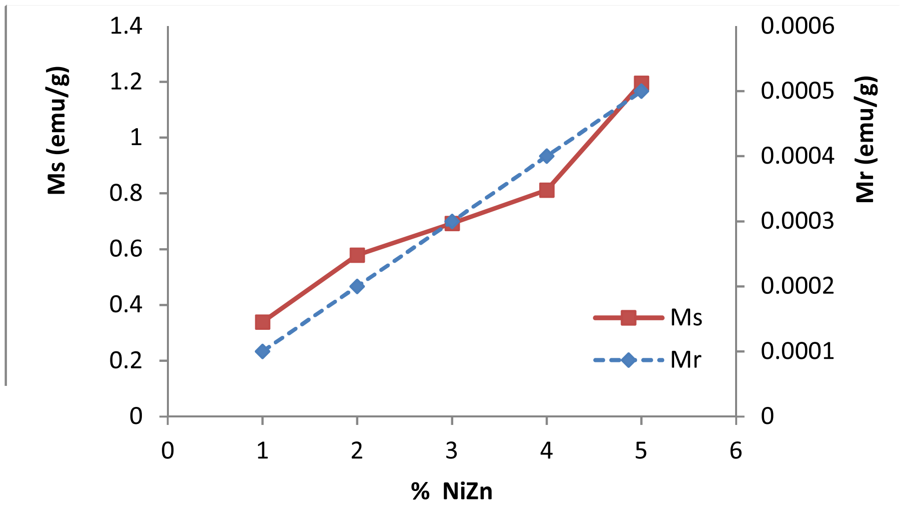

Fig. **4** Saturation magnetization and remenance magnetization of TPU/NR/LNR blends.

Ms value is very dependent on the effect of limited size. This impression includes changes in the average coordination number and the presence of an unbalanced spin rather than a break in symmetry at the border. Other characteristics are such as violence, relaxation and structural irregularities on the upper surface which increase the complexity of the filler system [6].

Saturation magnetization, remenance magnetization and magnetic field will be increases, when coercive force decreases with an increase in ferrite fillers [7, 8]. Coercive force is a forced force to return magnetizing of the material to zero. The coercive force can exhibit the sphere of ease of spin or magnetic moment for the filler to experience its original orientation towards the magnetic field in the matrix. If the saturation magnetization of the sample is retained, the magnetic moment will be forced to orient everything with a magnetic field. So that, the net magnetization becomes zero [6]. The orientation of a spin or magnetic fill moment is easy if the interaction of the magnetic moment between the ferrite filler is strong. This means, at a low fill composition, the initial orientation of the magnetic moment is predicted to be difficult because of the high obstacle or polymer matrix obstructions to the fill particle rotation.

According to Youyi [5] and El-Nashar [8], the value of Hc decreased with the increase in filler loading. This pattern may also be seen previously in figure above. They stated that, the decrease in Hc value when the load of NiZn ferrite fillers was added from 2% to 5% by weight was due to the increased magnetic interaction between NiZn ferrite. Yu [9] also stated in their study of natural rubber filled NiZn, that the value of Hc would be reduced at high filler load due to the increased magnetic interaction between in the matrix. However, he emphasized the high filler load when it exceeds 100% by weight. This phenomenon is also explained in the study of Ing [6] and Yu [9], where a uniform and random dispersion of fillers will reduce the average distance between the fillers in the polymer matrix and will add magnetic interactions.

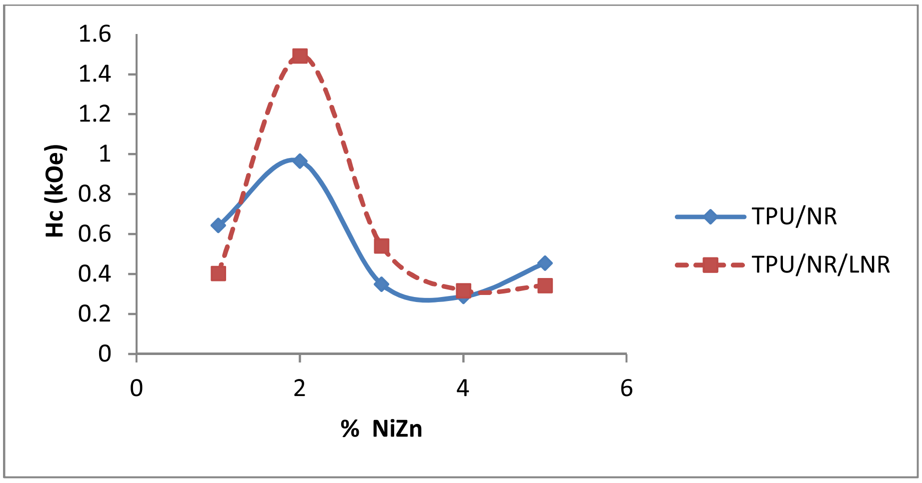

Fig. 5 Coercive forece of TPU/NR and TPU/NR/LNR blends.

If a comparison is made between the two types of composites in this study, it is found that both show the same graph plot style, but the graph plot for TPU / NR composites is lower. This shows, the filler scatter in this composite is better than the TPU / NR / LNR composite even though it can be seen, at 4% by weight of NiZn ferrite, the Hc values are almost the same and at 5% by weight, the TPU / NR / LNR composite is found to have lower Hc value. This may be due to the presence of LNR which can help in the spread of NiZn ferrite better than the matrix without LNR.

4 Conclusions

The saturation magnetization, Mr and remenance magnetization, Mr has increased. The other hand reduced the coercive force, Hc as parallel to the increasing of NiZn content. The magnetic filler should be well dispersed in the polymer matrix, thus will improve the properties of the blends. However, if the magnetic filler is more than the optimum percent, that can be represented by a matrix the filler is not well dispersed and tend to form agglomerates. The filler particles itself will tend to agglomerate due to the magnetic attraction between one another.

The authors would like to thank the Ministry of Higher Education Malaysia (MOHE) for the research fund under the Fundamental research Grant Scheme (FRGS) of the Project Code: FRGS/1/2018/TK05/UNIMAP/02/3).

References

1. N.A Ahad, & S.H Ahmad, J. of Sc. & Eng. Rsrch, 3(**4**) (2016)
2. N.A Ahad, N Parimin, & S.H. Ahmad, *Pro. Of Mech Eng Rsrch Day MERD2018* (2018)
3. N.A Ahad, S.H.Ahmad, & N.M. Zain, Adv Mat Rsrch, **795** (2013)
4. M.S Boon, W.P Serena & M.Mariatti, J. of Mgntsm and Mgntc Mat., **5** (2012)
5. Y. Sun, X. Zhou, Y. Liu, G. Zhao & Y. Jiang, Mat Rsrch Bul., **45** (2010)

6. I. Kong, S.H Ahmad M.H Abdullah, D.Hui, N. Yusoff, & D.Purniyati, J. of Mgntsm and Mgntc Mat, **21** (2010)
7. N.A Nassim, Y.Atassi, A. Solloum, A. Charba & A. Maliki, Mat Chem & Phy, **211** (2018)
8. D.E El-Nashar, Mater Des., **52** (2013)
9. L.J. Yu, S.H Ahmad, I.Kong, M.A Tarawneh, S.B.B Abd Razak, E. Natarajah & C.K Ang, *De Tech* (2019)