CHARACTERIZATION OF MECHANICAL AND ELECTRICAL PROPERTIES OF PC/ABS BASED HYBRID MATERIALS

Seong-Ho Jeon[1], Heon-Mo Kim[2], Tae-Hong Park[3], Byoung-Ho Choi[1*] and Woo-Chun Choi[1]

[1]School of Mechanical Engineering, Korea University, Seoul 136-713, Republic of Korea
[2]LG Chem, Ltd.. Technology Center, 84 Jang-dong, Yuseong-gu, Daejeon 305-343, Republic of Korea
[3] LG Electronics, 19-1 Cheongho-ri, Jinwi-myeon, Pyeongtaek-si, Gyounggi-do 451-713, Republic of Korea

Introduction

Automative industry now faces new industrial environment restriction. According to the 2005 Kyoto Protocol, some advanced countries now are trying to limit the amount of CO_2 emission. In the near future, it is expected that more countries will set the strict regulation on this sensitive issue. Therefore, most of automative companies have launched to develop new cars which have lighter weight than ever for the higher efficiency[1]. The weights of engineering polymers are only approximately 20% of steel, and the mechanical properties of them are very comparative. That is the reason why a number of studies have been conducted on engineering plastics in many automotive companies and universities.

Based on needs of lighter vehicle, audio systems in the vehicle are also interesting to look because a heavy metal frames have been used to cover electric circuits and mechanical parts. It is hardly found that the substitution of metals into polymers for this application due to two important properties, the electromagnetic interference (EMI) shielding effectiveness and the durability.

In this study, hybrid materials based on PC/ABS combined with carbon nanotubes (CNT), glass fibers and metal fiber are developed and characterized. Five hybrid materials with various contents of metal fibers were prepared, and fundamental mechanical properties, such as tensile and impact tests are conducted at various temperatures, flexural test, and EMI shielding effectiveness are measured. Finally, with considering test results and economical factors, the optimized hybrid material is selected among 5 compounds.

Experiments

Test Materials

As a base polymer of hybrid materials, PC/ABS was used, combined with glass fiber, CNT and metal fiber. PC/ABS is a good material for this application because of balanced mechanical properties and good moldability. Glass fiber [3] and CNT [4] have great thermal and mechanical properties. In this study, to control the mechanical and the EMI shielding properties, metal fibers were added [5]. To analyze the effect of metal fibers in hybrid materials, five different materials were prepared for various metal fibers, 1 wt%, 3 wt%, 5 wt%, 7 wt% and 10 wt%. Besides, 5 compounds were named as A, B, C, D and E. The formation of the compounds is shown in Table 1.

Table 1: Proportion of materials in PC/ABS(wt%)

	A	B	C	D	E
Glass Fiber	7				
CNT	1				
Metal Fiber	1	3	5	7	10

Test Methods

Three mechanical tests were conducted in this study: tensile, impact and flexural test. Considering the car driving conditions, tensile and impact tests were done at 3 different temperatures. The standards of the tests and temperature conditions are shown in Table 2.

Table 2: Test standards and Temperature conditions.

Test	**Tensile**	**Impact**	**Flexural**
Standard	ASTM D638	ISO 179	ASTM D790
Temperature condition	-40°C	-40°C	•
	24	24°C	24°C
	80°C	80°C	•

Measurement of EMI SE(Electromagnetic interference Shielding Efficiency) were done for the compounds by ASTM D4935 and sheet resistance of 'B' material was measured for various thicknesses by 4 point probe system. These tests are critical for electronic devices like car audios and navigation systems because these devices should pass the EMI standards, before being commercialized [6].

Results and discussion

Fig. 1 shows tensile strength for various metal fiber contents. The results show that tensile strength does not change according to the weight of metal fiber. However, temperature is an important factor. The lower the temperature is, the higher tensile strength is. But the amount of metal fibers (1 ~ 10 wt%) does not play an important role for improving tensile strength comparing with the temperature

Fig. 2 shows toughness for various metal fiber contents. Toughness is defined as fracture energy per unit volume. It is inversely proportional to metal fiber content. As the temperature increases, the toughness becomes low.

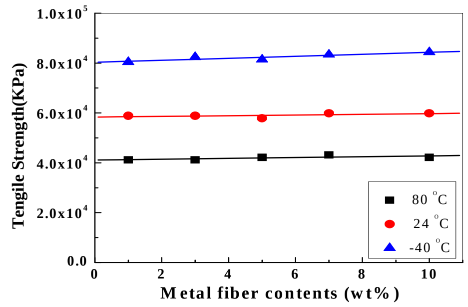

Fig. 1: Relationship between tensile strength and metal fiber contents for various temperatures.

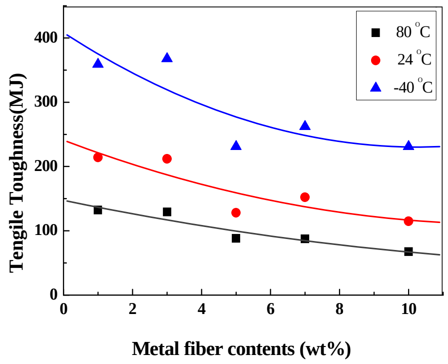

Fig. 2: Relationship between tensile toughness and metal fiber contents for various temperatures.

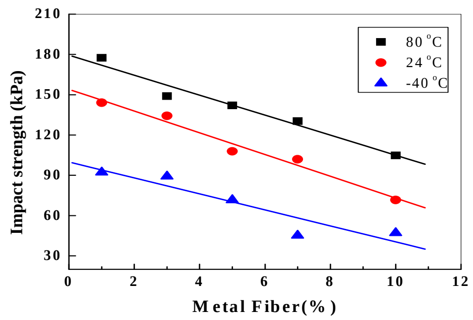

Fig. 3: Relationship between impact strength and metal fiber contents for various temperatures.

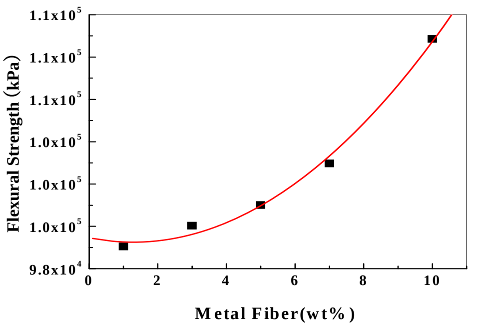

Fig.4: Relation between flexural strength and metal fiber contents at room temperature.

As shown in Fig. 3, impact strength is decrease as the weight of metal is higher and temperature is lower. This is caused by increasing the unstable interface between PC/ABS and metal fibers. In Fig. 4, flexural strength for various metal fiber contents is shown. Unlike tensile and impact strength, flexural strength increases with metal fiber content.

As shown in Table 3, measurement of EMI SE indicates that metal fiber content improves EMI shielding capability. Practically, 40 dB is a reasonable EMI SE for car audios [6], so at least 3wt% of metal fiber contents is needed. Besides, the thickness of the plate can be a factor for EMI SE, but measured EMI SE of samples with 2 and 3 mm does not show a big difference as shown in Table 4. By comparing all required properties and cost balances, 3 wt% of metal fiber is considered as an optimized one.

Table 3: Measured EMI SE values (3 mm thickness).

Samples	A	B	C	D	E
EMI SE @1GHz (dB)	15	46	48	61	67

Table 4: EMI SE and Sheet Resistance of B material

Thickness	1 mm	2 mm	3 mm
Sheet resistance(Ω/□)	5.9×10^8	8.8×10^8	10.0×10^8
EMI SE @1GHz(dB)	26	45	46

4. Conclusion

In this study, hybrid materials based on PC/ABS for EMI shielding with a proper mechanical properties are developed and characterized by changing metal fiber contents. By adding various metal fiber contents, EMI shielding property is improved rapidly and stabilized, and toughness of test materials decreases. But, the modulus and strength of test materials are more sensitive to the temperature variation rather than the metal fiber contents. The thickness of the plate can be a factor for EMI SE, but measured EMI SE for 2 and 3 mm samples doesn't show a big difference. By comparing all required properties and cost balance, 3 wt% of metal fiber is considered as an optimized one.

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