Effect of Fillers on Tribological Properties of EPDM with Hydrogen Exposure

Byeonglyul Choi[1)], Un Bong Baek[2)] and Byoung-Ho Choi[3)*]

[1,3)]School of Mechanical Engineering, Korea University, Republic of Korea
[2)]Korea Research Institute of Standards and Science, Republic of Korea.
*Corresponding author: bhchoi@korea.ac.kr

An ex-situ test was performed to understand the tribological characteristics of rubber materials used in a hydrogen environment. Ethylene-propylene-diene-monomer (EPDM) with different filler combinations was exposed to high-pressure hydrogen, and after 1 hour and 7 days, respectively, a pin-on-disc test was performed. Changes in wear resistance and wear mechanism according to filler combinations were observed before the specimens were exposed to hydrogen. After hydrogen exposure, the amount of wear increased in all specimens compared to before hydrogen exposure, and a similar wear mechanism was maintained. Morphology of wear track and cross-section were observed before and after hydrogen exposure using scanning electron microscope.

Keywords: hydrogen, EPDM, pin-on-disc, wear mechanism, functional fillers

1. Introduction

Hydrogen fuel cell vehicles (FCEVs) store high-pressure hydrogen gas (70 MPa) in a reinforced tank to increase fuel efficiency. Various rubber materials are used to seal each part from high-pressure hydrogen. However, when the rubber is exposed to high pressure hydrogen, swelling, blisters and cracks can happen in the material [1], [2]. Hydrogen induced damages affect mechanical and tribological properties of rubber. If the wear resistance of elastomeric seals is decreased, there can be a serious leakage in the sealing system. Therefore, it is important to understand the change of tribological properties of rubber after it is exposed to high-pressure hydrogen.

2. Materials

Ethylene-propylene-diene-monomer (EPDM) was made with different filler combination by Korea Institute of footwear & leather technology. Carbon black and silica were used as fillers, and the ratio is shown in Table 1.

Table 1: Filler content of EPDM

Filler Type	phr (part per hundred resin)			
	E-48	E-49	E-50	E-51
CB (N330)	-	112	80	48
Silica (S-175)	160	48	80	112

3. Methods

3.1. Hydrogen Exposure
EPDM specimens were exposed to 96.3 MPa of hydrogen for 24 hours using high pressure vessel in Korea Research Institute of Standards and Science.

3.2. Pin-On-Disc Wear Test
The wear testing conditions were normal load of 15 N, 150 rpm, and a total sliding distance of 250 m.

4. Results and Discussions

E-48 (only contains silica) showed the lowest amount of wear than the other specimens. In general, the amount of wear increased more after 1 hour from hydrogen exposure than before the exposure. At the time of 1 hour after decompression, hydrogen remains inside the rubber, and the hardness and tensile strength of rubber slightly decrease. When the wear test was conducted after 7 days from exposure to hydrogen, the amount of wear showed a tendency to increase. When the content of carbon black was higher than that of silica (E-49), the wear mechanism was changed to be brittle, and cracks were observed on the wear track (Figure 1).

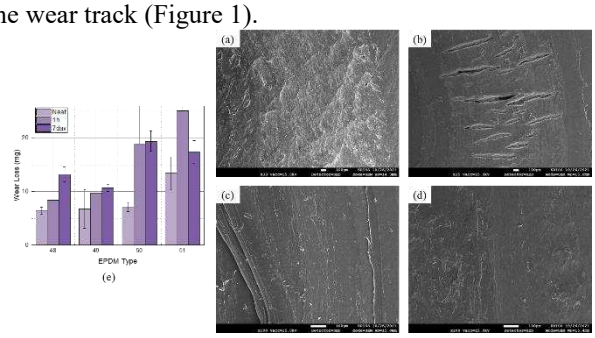

Figure 1: (a) wear track of E-48, (b) E-49, (c) E-50, (d) E-51, (e) wear loss after hydrogen exposure.

Although the hardness and wear resistance decreased, no noticeable damage was found when the cross-section was observed. Further analysis about effect of hydrogen on material properties is needed to understand the properties that do not recover after 7days from hydrogen exposure.

5. Conclusions

Content of fillers in EPDM affect the amount of wear as well as the wear mechanism. Regardless of fillers, exposure to hydrogen decreased the wear resistance of EPDM. No recovery of wear resistance was observed even after a long period of time from hydrogen exposure. More analysis is required to explain the phenomenon.

6. References

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