

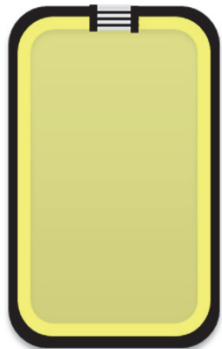
Degradation behavior of polymer materials in the high pressure hydrogen gas exposure

Polymer materials have an important role for the hydrogen storage cylinder. But it is not completely clarified how the high pressure hydrogen affects the polymer materials. The degradation behavior of the high density polyethylene molding exposed the high pressure H₂ gas is investigated by various analysis methods.

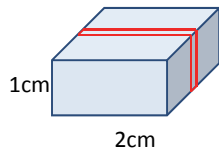
Schematic overview of the High pressure cylinder and the test sample

• Optical micrograph of the test specimen section
• Bending strength of the test specimen

Type-4
Surface layer: CFRP, liner: Resin

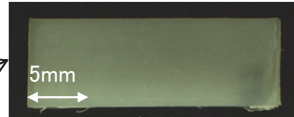


The test specimen

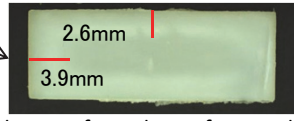


Sample:
High density polyethylene molding before and after the exposure test.

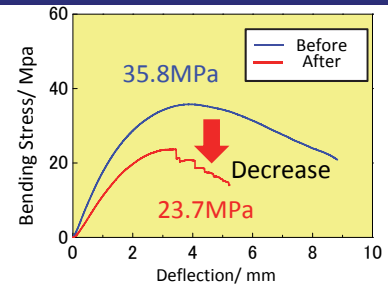
Before the test



After the test



The area from the surface to about 4mm in depth whitened by the exposure test.

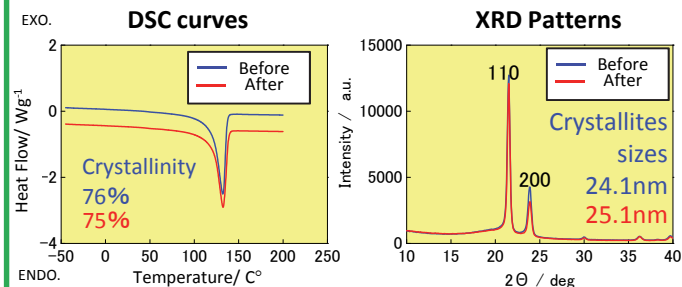


The bending strength was decreased and irregular stress liberation behavior was observed in the exposure sample.

Type-4 cylinders are more efficiency in manufacturing processes and lighter than the aluminum lined type-3.

Sub- μ m cavities and defect structure may be formed. The analysis focused on the crystal structure is performed using by following methods.

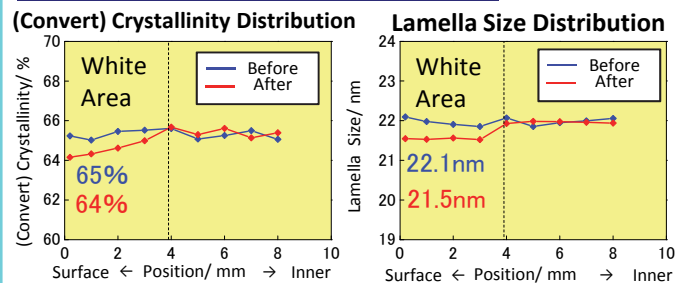
Crystal structure analysis by DSC and XRD



The crystallinity was slightly decreased after the test.

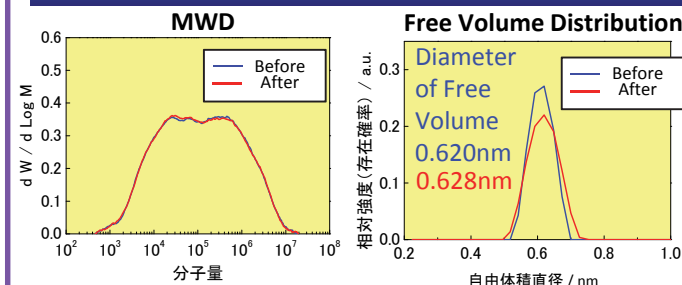
The crystallites sizes became slightly larger after the test.

Crystal structure distribution analysis by Raman spectroscopy



The (convert) crystallinity was decrease and lamella sizes became smaller in the white area.

• Molecular Weight Distribution (MWD) by GPC
• Free Volume Distribution by PALS



The MWD was not change before and after the test.

The free volume sizes became slightly larger after the test.

	Bending Strength	DSC	XRD
		Crystallinity	Crystallites size
Before	35.8MPa	76%	24.1nm
After	23.7MPa	75%	25.1nm

	Raman		GPC	PALS
	(Convert) Crystallinity	Lamella Size	Weight-average Molecular Weight M_w	Diameter of Free Volume
Before	65.2%	22.1nm	611000	0.620nm
After	64.2%	21.5nm	607000	0.628nm

After high pressure H₂ exposure test, the surface of the molding whitened and the bending strength was decrease. In the white area, the crystal and amorphous structure changed slightly. It is concluded that the changes of the appearance and the strength were caused by generation sub- μ m cavities and defect structure.