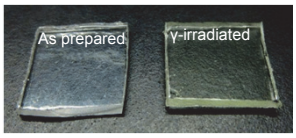
Investigation of the Effect of γ-irradiation on Physical Properties of Cyclo-Olefin Polymer (COP)

γ-irradiation is frequently used for sterilization of medical-care equipment. We investigated the effect of γ-irradiation on physical properties of cyclo-olefin polymer (COP). As a result, it was revealed that the oxidation and the formation of network structure such as cross-linkage occurred at the surface of COP by γ-irradiation.

Sample and Condition of γ-irradiation

Sample : Cyclo-Olefin Polymer (COP)
Condition of γ-irradiation : 50 kGy at RT (normal sterilization condition)



yellow discoloration by γ-irradiation

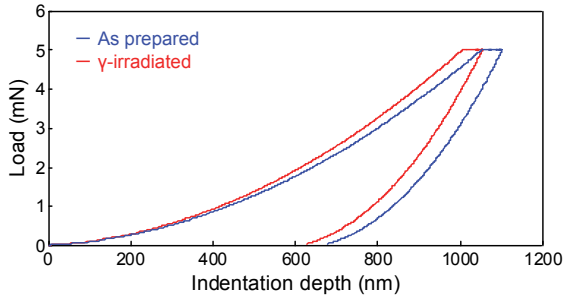
Results of Characterization

	Method	Evaluation item	As prepared	γ-irradiated	Change by γ-irradiation
Bulk	DSC	glass-transition temperature (Tg)	139.6℃	139.2℃	→
	Gas pycnometer	density	1.018 g/cm^3	1.018 g/cm^3	→
	GPC	molecular weight (Mw)	40500	43200	↑
Surface	AFM	roughness (Rms)	3.11 nm	3.16 nm	→
	Nano-indentation	Young's modulus	3.0 GPa	3.2 GPa	↑
		hardness	0.16 GPa	0.17 GPa	↑
	PALS*1	diameter of free volume	0.566 nm	0.550 nm	↓
	Contact angle	liquid : water	97.3°	81.1°	↓
		surface free energy*2 γ_S	37.9 mN/m	44.8 mN/m	↑
		dispersion component γ_S^D	34.2 mN/m	33.5 mN/m	↓
		polar component γ_S^P	2.9 mN/m	9.5 mN/m	↑
		hydrogen-bonding component γ_S^H	0.7 mN/m	1.8 mN/m	↑

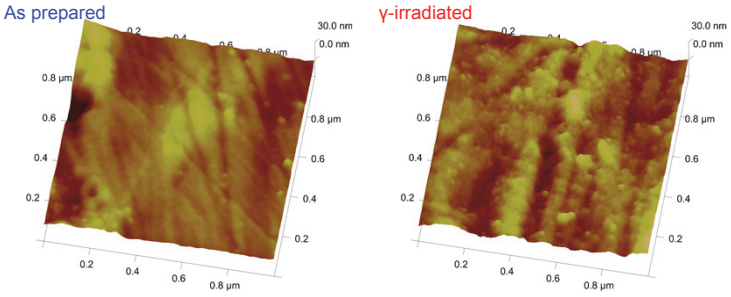
*1 : Positron annihilation lifetime spectroscopy

*2 : Dispersion, polar, and hydrogen-bonding components were estimated from the contact angle measurements by water, formamide, diiodomethane, and ethylene glycol. Surface free energy is the sum total of dispersion, polar, and hydrogen-bonding components. $\gamma_S = \gamma_S^D + \gamma_S^P + \gamma_S^H$

◆Young's modulus and hardness by nano-indentation



◆AFM observation of COP surface



γ-irradiated COP has more microstructures.

Discussion

・γ-irradiation has caused the increase of molecular weight, Young's modulus, hardness and the decrease of free volume, which indicated the formation of network structure such as cross-linkage.

・γ-irradiation has caused the increase of polar and hydrogen-bonding components and the decrease of dispersion component, which indicated the oxidation of COP surface.
[FTIR spectrum (not shown here) showed the generated hydroxyl and carbonyl groups.]