Supporting Information for

Improvement of the transparency, mechanical, and shape memory properties of polymethylmethacrylate/titania hybrid films using tetrabutylphosphonium chloride

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Sample	Tier	TBPC	Polymer-	THF .	TiOPr .	. THE .	TBPC.	THE	- 1M HCI	THE
name	(wt%)	(wt%)	$\operatorname{Ie}\operatorname{ST}_{(g)}$	reparati	on cond	itions fo	or each	hybrid fi	$\lim_{(\mu L)}$	(μL)
Ti0TB0	0	0	2.5	80.1	0	5.0	0	0	25	282
Ti5TB0	5	0	2.5	80.1	0.13	5.0	0	0	25	282
Ti10TB0	10	0	2.5	80.1	0.26	5.0	0	0	25	282
Ti15TB0	15	0	2.5	80.1	0.39	5.0	0	0	25	282
Ti15TB10	15	10	2.5	80.1	0.39	5.0	0.25	1.0	25	282
Ti15TB20	15	20	2.5	80.1	0.39	5.0	0.5	2.0	25	282
Ti15TB40	15	40	2.5	80.1	0.39	5.0	1.0	4.0	25	282
Ti0TB40	0	40	2.5	80.1	0	5.0	1.0	4.0	25	282







Figure S3 Stress-strain curves of titania hybrid co-PMMA films. (a) 5 wt% titania precursor, (a) 10 wt% titania precursor, (c) 15 wt% titania precursor.

TGA measurement of each hybrid film

The TGA results for each hybrid film are shown in Figure S4. These measurements were carried out in air at a heating rate of 3 °C min⁻¹. Temperature at 5% weight loss for each hybrid film was Ti15TB0 (190°C), Ti15TB10 (191°C), Ti15TB20 (191°C), and Ti15TB40 (200°C). Residual material at 800°C, which indicates the titania content, were Ti15TB0 (11%), Ti15TB10 (9.4%), Ti15TB20 (8.4%), and Ti15TB40 (9.4%).



Figure S4 TGA thermograms of each hybrid film in air at a heating rate of 3°C/min: Ti0TB0 (dark red line), Ti15TB0 (black line), Ti15TB10 (red line), Ti15TB20 (blue line), and Ti15TB40 (green line).



Figure S5 FT-IR spectra of titania hybrid films: Ti0TB0 (red line), Ti5TB0 (blue line), Ti10TB0 (green line), and Ti15TB0 (black line). (b) Enlarged view of IR spectrum at 3100–2800 nm (c) Enlarged view of IR spectrum at 1200–900 nm



Figure S6 FT-IR spectrum of TBPC.

SMP Definitions

The shape-fixing ratio (Rf) and the shape-recovery ratio (Rr) are the most frequently used parameters to determine the efficiency of shape memory properties. The shape-fixing ratio is calculated according to equation 1:

$$R_{f} = (\mathcal{E}_{u} / \mathcal{E}_{100}) \times 100\% (1)$$

Where \mathcal{E}_{100} is the strain at 100°C with applied stress and fixing and \mathcal{E}_u is the strain after the removal of stress. The strain recovery ratio is calculated according to equation 2:

$$R_r = (E_u - E_{rec}) / E_u \times 100\% (2)$$

where \boldsymbol{E}_{rec} is the strain after recovery.

The heat shrinkage ratio is calculated according to equation 3:

$$R_{fi} = (\epsilon_{100} - \epsilon_{25}) / \epsilon_{25} \times 100\%$$
 (3)

where \mathcal{E}_{25} is the strain at 25°C when applying stress.



Figure S7 Shape-memory programming for Ti15TB0 with 0.4 MPa of applied stress.

Table S2 Summary of the strain under various conditions, values of the shape fixing ratio (Rf) and the shape recovery ratio (Rr).

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