Supplementary Material

Manuscript Title: Mechanical Properties and Microscopic Mechanisms of Butyl Rubber Sealing Materials under Multiple Aging Conditions

Table S1. Raw data and statistical results of tensile tests under low-temperature aging

Time (d)	Specimen No.	Tensile bonding strength (MPa)	Elongation at break (%)
7	1	0.0607	244.6
7	2	0.0625	248.0
7	3	0.0629	250.8
	Mean ± SD	0.0620 ± 0.0012	247.8 ± 3.1
	CV (%)	1.89	1.25
14	1	0.0612	249.1
14	2	0.0628	252.4
14	3	0.0632	254.2
	Mean ± SD	0.0624 ± 0.0011	251.9 ± 2.6
	CV (%)	1.70	1.03
35	1	0.0630	252.9
35	2	0.0645	255.7
35	3	0.0654	258.2
	Mean ± SD	0.0643 ± 0.0012	255.6 ± 2.7
	CV (%)	1.89	1.04
56	1	0.0636	257.0
56	2	0.0654	260.5
56	3	0.0660	261.6
	Mean ± SD	0.0650 ± 0.0012	259.7 ± 2.4
	CV (%)	1.92	0.92
84	1	0.0640	260.6
84	2	0.0656	264.9
84	3	0.0663	267.7
	Mean ± SD	0.0653 ± 0.0012	264.4 ± 3.6
	CV (%)	1.81	1.35

Table S2. Raw data and statistical results of tensile tests under UV aging

Time (d)	Specimen No.	Tensile bonding strength (MPa)	Elongation at break (%)
0	1	0.0530	218.1
0	2	0.0546	220.1
0	3	0.0547	220.6
	Mean ± SD	**0.0541 ± 0.0010**	**219.6 ± 1.3**
	CV (%)	**1.76**	**0.60**
7	1	0.0512	217.0
7	2	0.0526	219.7
7	3	0.0531	220.6
	Mean ± SD	**0.0523 ± 0.0010**	**219.1 ± 1.9**
	CV (%)	**1.88**	**0.86**
14	1	0.0490	217.0
14	2	0.0504	221.0
14	3	0.0512	221.4
	Mean ± SD	**0.0502 ± 0.0011**	**219.8 ± 2.4**
	CV (%)	**2.22**	**1.11**
21	1	0.0489	219.5
21	2	0.0500	221.7
21	3	0.0511	223.0
	Mean ± SD	**0.0500 ± 0.0011**	**221.4 ± 1.8**
	CV (%)	**2.20**	**0.80**
28	1	0.0473	216.4
28	2	0.0484	218.1
28	3	0.0492	219.5
	Mean ± SD	**0.0483 ± 0.0010**	**218.0 ± 1.6**
	CV (%)	**1.98**	**0.71**
35	1	0.0470	221.3
35	2	0.0483	223.2
35	3	0.0493	225.1
	Mean ± SD	**0.0482 ± 0.0012**	**223.2 ± 1.9**
	CV (%)	**2.39**	**0.85**

Table S3. Raw mechanical data for high-temperature aging

Temperature (°C)	Specimen No.	Tensile bonding strength (MPa)	Elongation at break (%)
40	1	0.0239	191.7
40	2	0.0223	189.3
40	3	0.0222	192.4
	Mean ± SD	**0.0228 ± 0.0010**	**191.1 ± 1.6**
	CV (%)	**4.18**	**0.85**
50	1	0.0191	167.1
50	2	0.0167	163.4
50	3	0.0166	170
	Mean ± SD	**0.0175 ± 0.0014**	**166.8 ± 3.3**
	CV (%)	**8.10**	**1.98**
60	1	0.0143	130.3
60	2	0.0119	132.8
60	3	0.01	126.7
	Mean ± SD	**0.0121 ± 0.0022**	**129.9 ± 3.1**
	CV (%)	**17.86**	**2.36**
70	1	0.0093	88.4
70	2	0.0073	89.1
70	3	0.0068	94.9
	Mean ± SD	**0.0078 ± 0.0013**	**90.8 ± 3.6**
	CV (%)	**16.96**	**3.93**
80	1	0.0066	49.8
80	2	0.0040	35.3
80	3	0.0053	42.7
	Mean ± SD	**0.0053 ± 0.0013**	**42.6 ± 7.3**
	CV (%)	**24.53**	**17.02**

Table S4. Statistical results of One-way ANOVA and verification tests.

Dependent Variable	Grouping	F-value	df (Between, Within)	Exact p-value	Shapiro-Wilk (p)	Levene's (p)	Post-hoc Test (Tukey's HSD)
High-temp Tensile	40–80 ℃	69.28	(4, 10)	< 0.0001	> 0.05	> 0.05	40 °C differs significantly from 50–80 °C groups ($p < 0.05$)
High-temp Elongation	40–80 ℃	599.08	(4, 10)	< 0.0001	> 0.05	> 0.05	All groups differ significantly from each other ($p < 0.05$)
Low-temp Tensile	7–84 d	5.04	(4, 10)	0.0174	> 0.05	> 0.05	Significant difference between 7d and 84d ($p < 0.05$)
Low-temp Elongation	7–84 d	15.06	(4, 10)	0.0003	> 0.05	> 0.05	Significant difference between 7d and 84d ($p < 0.05$)
UV Tensile	0–35 d	14.61	(5, 12)	< 0.0001	> 0.05	> 0.05	0d differs significantly from 28d and 35d ($p < 0.05$)
UV Elongation	0–35 d	3.01	(5, 12)	0.0546	> 0.05	> 0.05	No significant difference ($p > 0.05$)