

Accelerated Aging of Surgical N95 filtering facepiece respirator (FFR) Straps: Pressure Reactor vs. Oven Aging Methods: Supplemental Materials

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S1. Scanning Electron Microscope Analysis

The SEM images of the unaged and aged respirator straps treated with oven aging at 70 °C and pressurized reactor aging at 25 °C and 40 bar O₂ for Respirator A, Respirator B, and Respirator C are shown in Figure S1. The SEM images show the presence of small, visible flakes in the oven-aged Respirator A and Respirator B straps, while Respirator C displays slightly more visible alterations with aging. The unaged Respirator C samples exhibit open pores; however, aging induces a noticeable transition toward patches of closed pores in their morphology. High-pressure reactor aging at 25 °C and 40 bar O₂ showed a similar morphology change as oven aging at 70 °C.

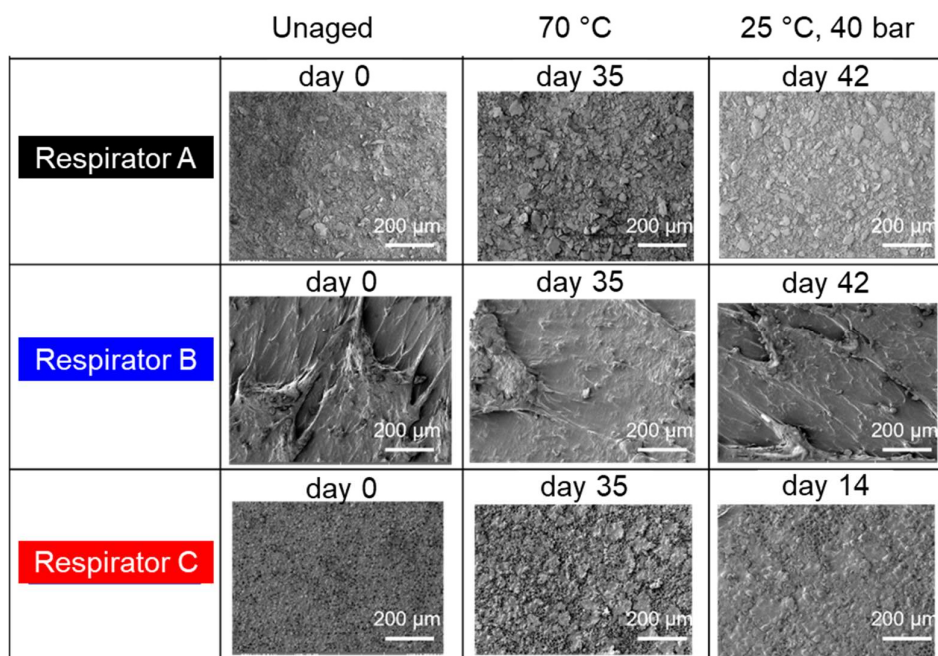


Figure S1: SEM images of Respirator A, Respirator B, and Respirator C. Unaged (control) samples are presented in the first column, oven aging samples at 70 °C are presented in the second column, and reactor aging at 25 °C with 40 bar O₂ samples are in the third column.

S2. Tensile Tests

The mechanical properties of the strap include modulus (stiffness), breaking force (maximum force-bearing capacity), elongation at break (maximum elongation before failure), and toughness (energy for failure).

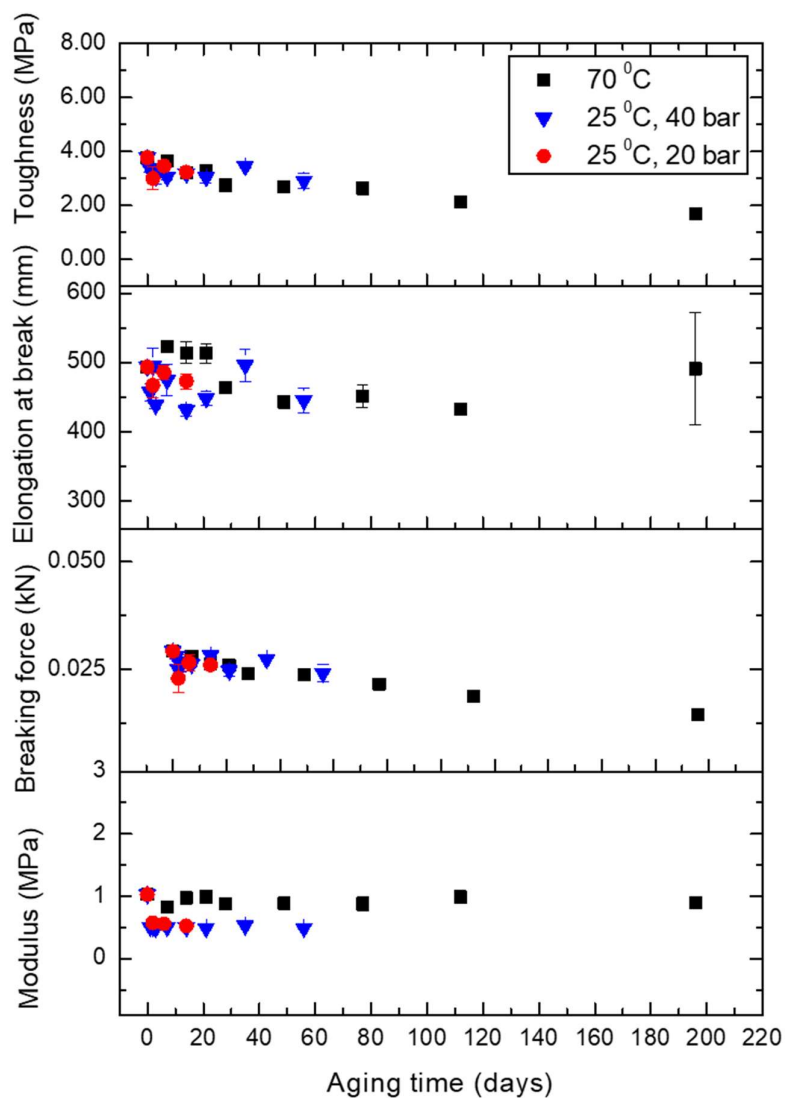


Figure S2: Mechanical properties versus aging time for Respirator A. Modulus, breaking force, elongation at break, and toughness are plotted against accelerated aging time. Oven aging at 70 °C (black rectangular symbols) and reactor aging at 25 °C, 40 bar (blue triangle symbols) and 20 bar O₂ (red circular symbols), are plotted.

Supplemental Materials

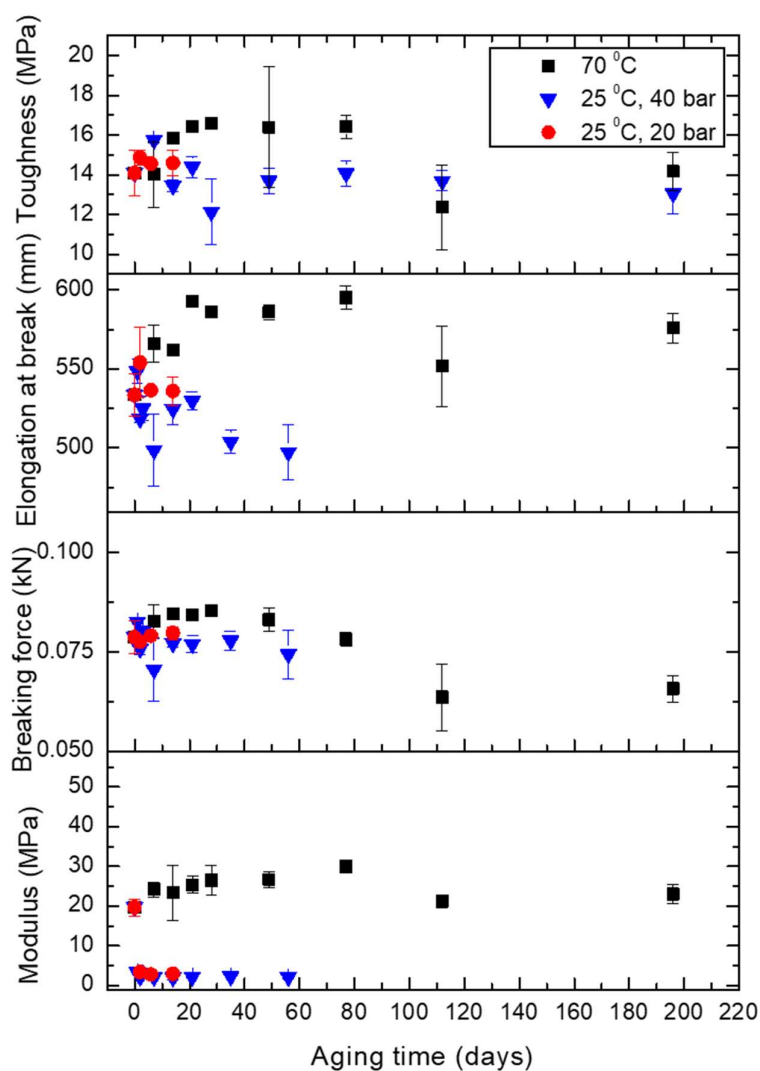


Figure S3: Mechanical properties versus aging time graph of Respirator B. Modulus, breaking force, elongation at break, and toughness are plotted against accelerated aging time. Oven aging at 70 °C (black rectangular symbols) and reactor aging at 25 °C, 40 bar (blue triangle symbols) and 20 bar O₂ (red circular symbols), are plotted.

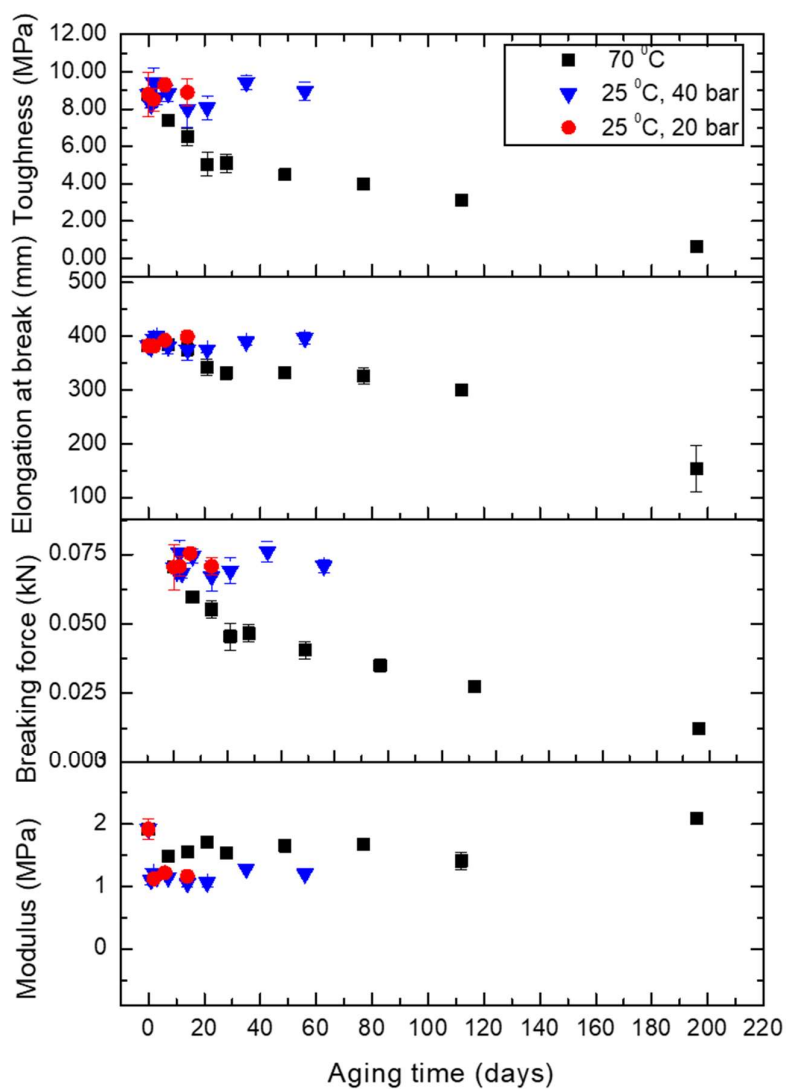


Figure S4: Mechanical properties versus aging time graph of Respirator C. Modulus, breaking force, elongation at break, and toughness are plotted against accelerated aging time. Oven aging at 70 °C (black rectangular symbols) and reactor aging at 25 °C, 40 bar O₂ (blue triangle symbols) and 20 bar O₂ (red circular symbols), are plotted.

S3. Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) Analysis

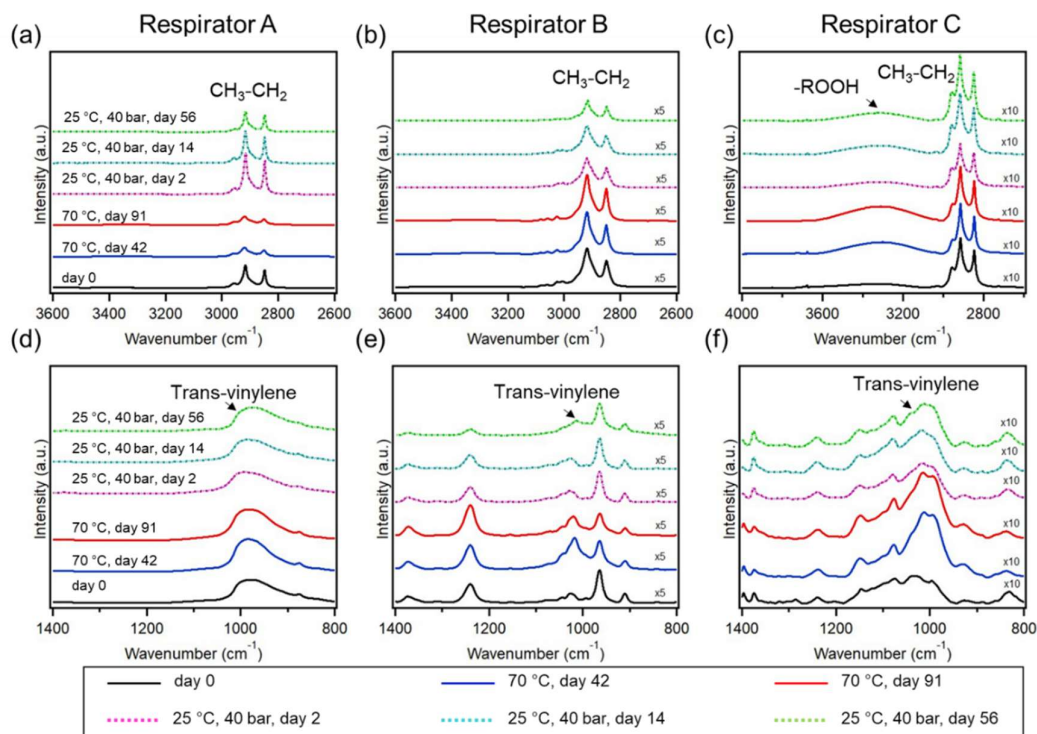


Figure S5: ATR-IR spectra of $\text{CH}_3\text{-CH}_2$, -OH and, trans vinylene region of Respirator A (a), (d); Respirator B (b), (e); and Respirator C (c), (f). Untreated straps at day 0, oven-aged samples at 70 °C on day 42 and day 91, and high-pressure reactor-aged samples at 25 °C with 40 bar O_2 on day 2, day 14, and day 56 are compared. The arrows showed distinct functional groups for oxidation: $\text{CH}_3\text{-CH}_2$ region (2800-2900 cm^{-1}), ---ROOH region (3350-34500 cm^{-1}), and trans-vinylene ($\text{-CH}_2\text{=CH}_2\text{-}$), ethers and other -C-O-C regions (400-1400 cm^{-1}). Distinct degradation mechanisms observed through spectral analysis highlight different aging behaviors between oven and reactor aging processes over time. Note: Captions for B and C are the same as A, and captions for E and F are the same as D due to space constraints.

Table S1 Tensile data measurement of oven aging at 70 °C for Respirator A

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.03	0.03	3.77	493.68
7	0.53	0.03	3.63	522.48
14	0.97	0.03	3.21	513.95
21	0.99	0.03	3.28	512.90
28	0.88	0.02	2.75	463.28
49	0.89	0.02	2.69	443.21
77	0.87	0.02	2.65	451.44
112	0.99	0.02	2.12	432.89
196	0.90	0.01	1.68	491.01

Table S2: Tensile data measurement of oven aging at 70 °C for Respirator B.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	20	0.08	533.43	14.08
7	24	0.08	565.92	14.02
14	23	0.08	561.76	15.84
21	25	0.08	592.82	16.44
28	26	0.09	586.11	16.59
49	27	0.08	585.77	16.38
77	30	0.08	594.93	16.40
112	21	0.06	551.57	12.34
196	23	0.07	575.79	14.16

Table S3: Tensile data measurement of oven aging at 70 °C for Respirator C.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.92	0.07	382.15	8.77
7	1.31	0.06	384.99	7.41
14	1.26	0.06	374.97	6.50
21	1.70	0.05	342.31	5.04
28	1.53	0.05	331.31	5.10
49	1.65	0.04	332.21	4.48
77	1.68	0.03	326.34	3.96
112	1.40	0.03	300.24	3.11
196	2.09	0.01	153.61	0.64

Table S4: Tensile data measurement of reactor aging at 25 °C with 40 bar O₂ for Respirator A.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.03	0.029	493.68	3.8
1	0.50	0.028	456.94	3.4
2	0.50	0.025	494.37	3.2
3	0.49	0.027	438.64	3.1
7	0.51	0.026	474.51	3.1
14	0.50	0.028	430.95	3.2
21	0.49	0.025	448.02	3.0
35	0.53	0.027	495.91	3.5
56	0.49	0.024	445.24	2.9

Supplemental Materials**Table S5:** Tensile data measurement of reactor aging at 25 °C with 40 bar O₂ for Respirator B.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	19.65	0.08	533.43	14.1
1	3.32	0.08	548.48	15.7
2	2.14	0.08	518.13	13.4
3	3.18	0.08	524.88	14.4
7	2.06	0.07	498.35	12.1
14	2.01	0.08	524.35	13.7
21	2.17	0.08	529.46	14.1
35	2.28	0.08	503.70	13.7
56	2.09	0.07	497.06	13.1

Table S6: Tensile data measurement of reactor aging at 25 °C with 40 bar O₂ for Respirator C.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.92	0.070	382.15	8.77
1	1.10	0.069	379.52	8.22
2	1.21	0.076	395.14	9.43
3	1.14	0.068	399.65	8.55
7	1.14	0.074	380.15	8.84
14	1.05	0.067	374.64	8.00
21	1.06	0.069	375.18	8.07
35	1.28	0.076	389.83	9.42
56	1.20	0.071	396.09	8.94

Table S7: Tensile data measurement of reactor aging at 25 °C with 20 bar O₂ for Respirator A.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.03	0.03	493.68	3.77
2	0.57	0.02	467.21	3.00
6	0.55	0.03	486.24	3.46
14	0.52	0.03	472.98	3.23

Table S8: Tensile data measurement of reactor aging at 25 °C with 20 bar O₂ for Respirator B.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	19.65	0.08	533.43	14.08
2	3.39	0.08	553.96	14.86
6	2.79	0.08	536.51	14.56
14	2.95	0.08	535.82	14.59

Supplemental Materials**Table S9:** Tensile data measurement of reactor aging at 25 °C with 20 bar O₂ for Respirator C.

Time (Day)	Modulus (MPa)	Breaking force (kN)	Displacement at break (mm)	Toughness (MPa)
0	1.92	0.07	382.15	8.77
2	1.12	0.07	381.65	8.52
6	1.22	0.08	392.14	9.29
14	1.16	0.07	398.97	8.89