Supplemental Information

Development of Wearable Air-Conditioned Mask for Personal Thermal Management

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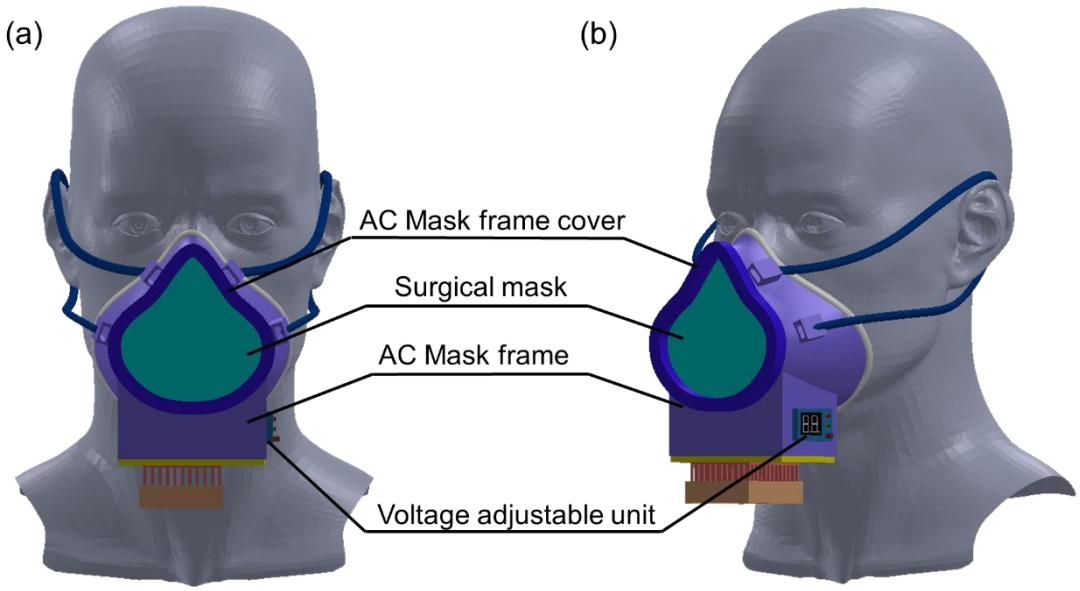

Figure S1. Illustration of AC Mask with (a) Front view (b) Side view.

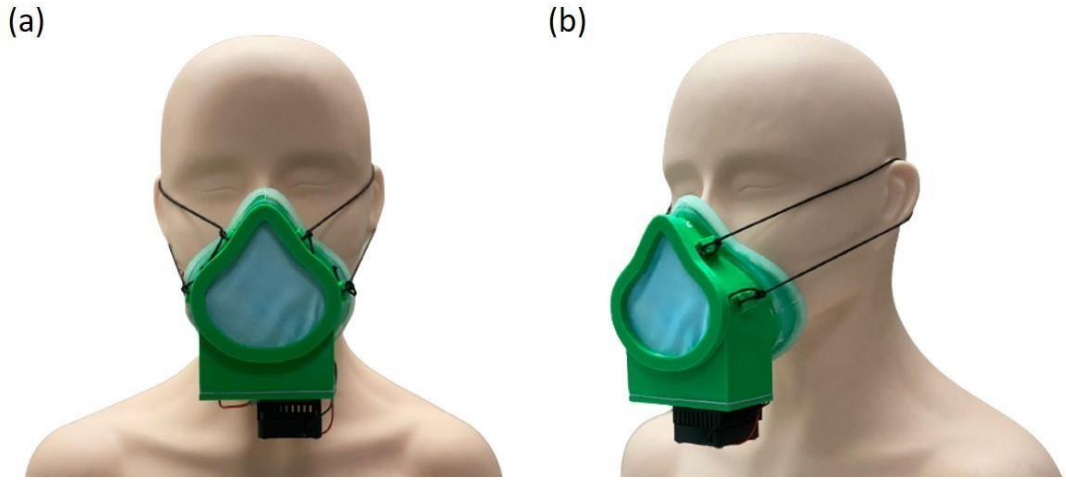

Figure S2. Prototype of AC Mask with (a) Front view (b) Side view.

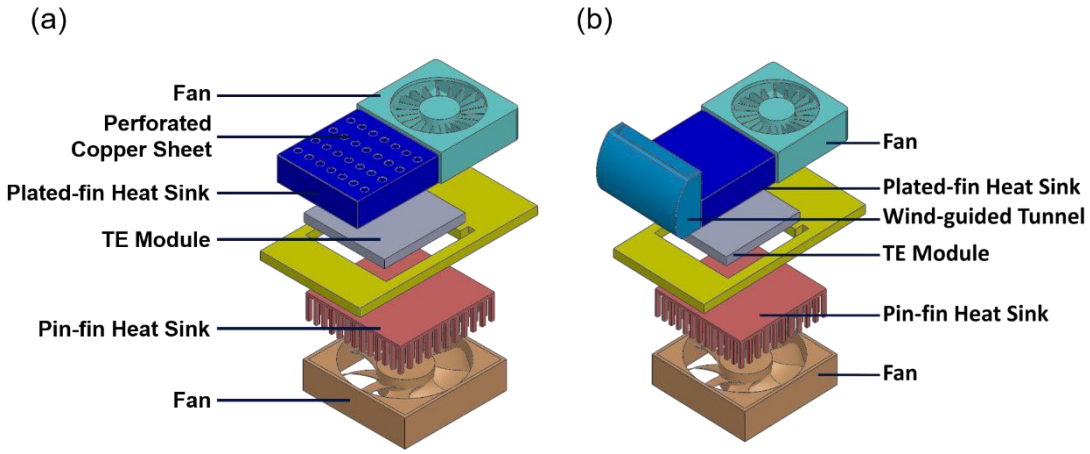

Figure S3. Illustration of thermoregulation unit in the AC Mask, with the heat exchanger made from (a) an aluminum plate-fin heat sink covered with a thin perforated copper sheet and (b) a plate-fin heat sink covered by an impermeable copper sheet with a 3D-printed wind-guided tunnel.

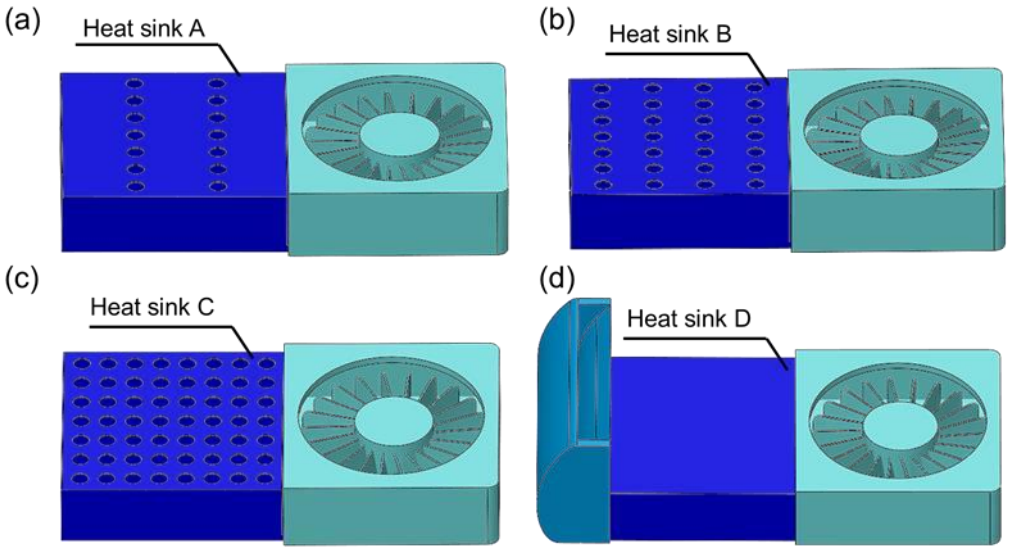

Figure S4. Structure of heat exchangers with (a) 2 rows of holes for each channel in the heat sink A, (b) 4 rows of holes for each channel in the heat sink B, (c) 8 rows of holes for each channel in the heat sink C, and (d) the wind guide in the heat sink D.

Supplementary Note 1: The filtration performance of the AC Mask

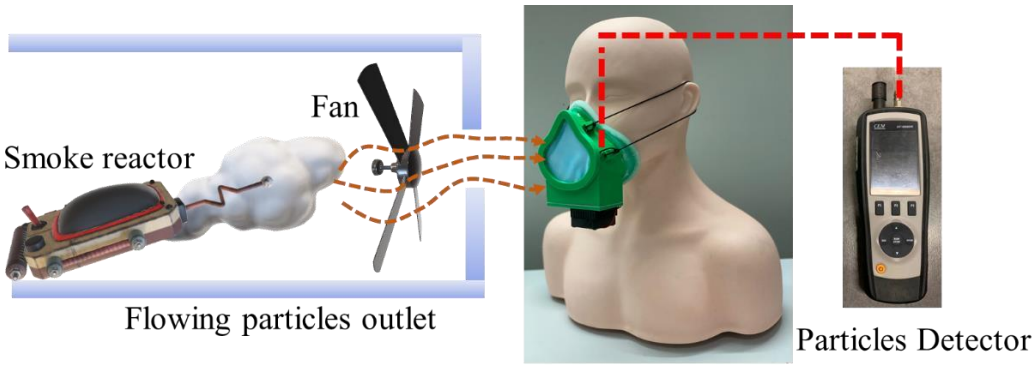

Figure S5. The filtration test setup of the proposed mask

Fig. S6 shows the enhanced filtration performance by the AC Mask compared to 3M™ N95. For example, the particle concentration of 0.3 μm has been reduced from 64.9 mg/m^3 to 1.69 mg/m^3. The reduced percentage for overall particles reaches as high as 80%-97%. The mechanism of the enhanced filtration performance is the better sealant of the proposed mask compared to the traditional mask. As reported by Xu M. et al. [1], a 5% gap between the mask and face can lead to a more than 60% reduction in filtration performance. The proposed mask effectively solves the sealant issue between the mask and face.

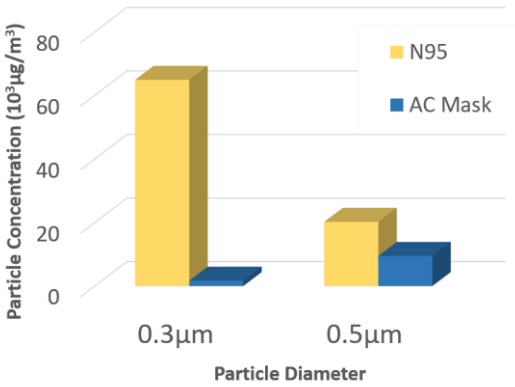

Figure S6. The comparison of particle concentrations induced by 3M™ N95 and AC Mask

Table

S1. Details of the Thermoregulation Unit

	Hot Side			Cold Side				
	Heat Sink	Fan	TE	Heat Sink				Fan
Code	2	A	TEC1-7104SR	A	B	C	D	G
Dimensions ± 1 (mm) (L(mm)*W(mm) *H(mm))	40*40*10	40*40*10	30*30*5	30*30*5	30*30*5	30*30*5	30*30*5	30*30*6.5
Air Blow Direction	-	Blowing Forward	-	-	-	-	-	Side Blowing

Table
S2. Details of the AC Mask Weight

	AC Mask Frame	Thermoregulation Unit	Voltage Adjustable Unit	Desiccant Bags	**Total Weight**
Weight (g) ± 0.05 (g)	92.29	81.85	14.37	5.00	**193.51**

Table
S3. Scales for thermal sensation and thermal preference [2]

Scale	Thermal Sensation Vote (TSV) (ASHRAE)	Thermal Preference (TP)
-3	Cold	
-2	Cool	Much cooler
-1	Slightly cool	A bit cooler
0	Neutral (neither cool nor warm)	No change
1	Slightly warm	A bit warmer
2	Warm	Much warmer
3	Hot	

Note: ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Table
S4. Scale for humidity feeling and humidity preference [2]

Scale	Humidity feeling (HF)	Humidity Preference (HP)
-3	Very dry	
-2	Dry	Prefer much drier
-1	Slightly dry	Prefer slightly drier
0	Neither humid nor dry	No change
1	Slightly humid	Prefer slightly more humid
2	Humid	Prefer much more humid
3	Very humid	

Table
S5. Scale for overall comfort [3]

Scale	Overall Comfortable (OC)
-3	Very comfortable
-2	Moderately comfortable
-1	Slightly comfortable
0	Neither comfortable nor uncomfortable
1	Slightly uncomfortable
2	Moderately uncomfortable
3	Very uncomfortable

Table

S6. Results of subjective evaluations

Facemask	Var.	TSV	TP	HF	HP	OC
AC Mask	Mean	-1.13	-1.20	-0.80	0.27	-0.73
	SD	0.92	0.77	1.08	0.70	1.39
N95 Mask	Mean	2.13	-2.27	2.13	-2.00	1.80
	SD	0.74	0.70	0.74	0.93	0.77

Supplementary Reference

[1] M. Xu, P. Lee, D.J.P.o. Collins, The critical importance of mask seals on respirator performance: An analytical and simulation approach, 16(2) (2021) e0246720.
[2] S.A. Damiati, S.A. Zaki, H.B. Rijal, S.J.B. Wonorahardjo, Environment, Field study on adaptive thermal comfort in office buildings in Malaysia, Indonesia, Singapore, and Japan during hot and humid season, 109 (2016) 208-223.
[3] M. Indraganti, R. Ooka, H.B.J.B. Rijal, Environment, Thermal comfort in offices in summer: Findings from a field study under the 'setsuden'conditions in Tokyo, Japan, 61 (2013) 114-132.