Supplementary Material

Standardization of hydrogen peroxide

Standardization of 30 mmol/L hydrogen peroxide (stock solution) was performed by pipetting 20 mL stock solution (I) in a 125 mL Erlenmeyer flask. 2 mL of 25% (w/w) sulfuric acid was added and titrated with 20 mmol/L potassium permanganate ($KMnO_4$, CAS 7722-64-7) until a pinkish color appeared. The redox reaction of potassium permanganate and hydrogen peroxide follows the stoichiometry in Eq 1. An exact concentration of stock solution (II) was calculated as in Eq 1.

20 mmol/L of $KMnO_4$ was prepared from drying $KMnO_4$ in an oven at 105°C for three hours. 0.8 g of $KMnO_4$ was weighed and dissolved in 250 mL deionized water.

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2 \qquad \text{Equation 1}$$

$$H_2O_2(mmol/L) = \frac{5}{2}\ x\ \frac{[C]\ x\ V_2}{V_1} \qquad \text{Equation 2}$$

Where [C] is the concentration of $KMnO_4$ in mmol/L, V_1 is the volume in mL of H_2O_2 used for the titration and V_2 is the volume in mL of $KMnO_4$ at the end point of the titration.

Table S1: N95 masks

Mask	model	Shape	Manufacturer	Mask wt (g)
A	3M 1860	thick cupped-type	3M Company USA	10.7 to 12.4
B	3M 8210	thick cupped-type		9.0 to 9.5
C	3M 9205	thin folded-type		8.4 to 8.7
D	FT-N040	thin folded-type	Suzhou Fangtial Industries Co. Ltd, China	7.2 g to 8.6
E	FT-N058	thick cupped-type		10.4 g to 11.6
F	Gerson 2130	thin cupped-type	Louis M. Gerson Co., Inc. US	9.9 g to 10.5

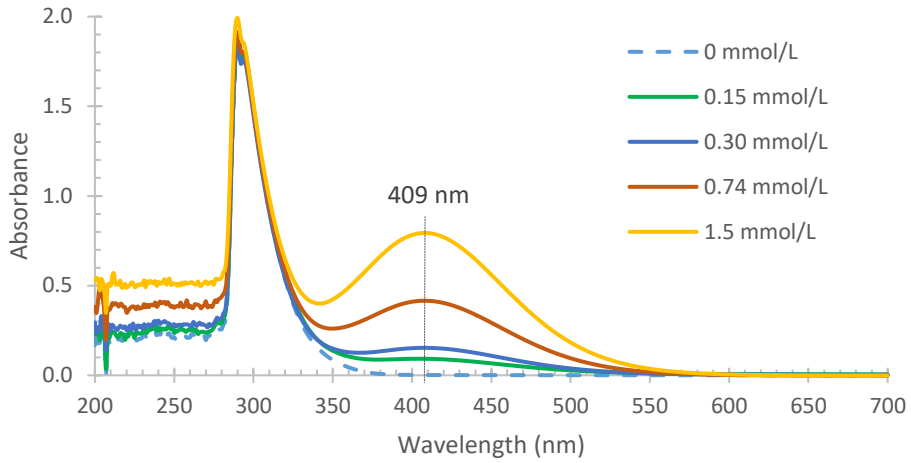

Figure S1: UV-Vis absorption spectrum of a peroxo-titanium complex solution from 200 -700 nm

Limit of detection and limit of quantification determination

$$A_{LOD} = A_{blank} + (3\ x\ SD)$$ Equation 3

Where A is absorbance of blank solution and SD is standard deviation of absorbance average at the lowest concentration (0.015 mmol/L) from Table S2.

Table S2: Limit of detection (LOD) of hydrogen peroxide by a colorimetric method

Concentration (mmol/L)	Absorbance 1st reading	Absorbance 2nd reading	Absorbance 3rd reading	Absorbance average	Standard deviation (SD)
0	0.0056	0.0054	0.0057	0.0058	0.0006
0.015	0.0195	0.0197	0.0199	0.0194	0.0005
0.059	0.0293	0.0298	0.0285	0.0290	0.0005
0.153	0.0772	0.0775	0.0763	0.0775	0.0009
0.259	0.1319	0.1319	0.1315	0.1328	0.0024
0.765	0.3919	0.3916	0.3925	0.3923	0.0005
Linear equation	A = 0.5046X+0.0041 Where A is the absorbance, and X is the concentration			Correlation coefficient (R) = 0.9989	

LOD for solution	$$X_{LOD} = \frac{A_{LOD} - 0.0041}{0.5046}$$ $$A_{LOD} = Abs_{blank} + (3SD_{Abs\ blank}) = 0.0058 + (3x0.0006)$$ Where A_{LOD} is the summation of absorbance of blank solution and three times of standard deviation of blank solution. $$X_{LOD} = \frac{\big(0.0058 + (3\text{x}0.0006)\big) - 0.0041}{0.5046} = 0.0069\ \text{mmol/L}$$ Where X_{LOD} is the limit of detection of H_2O_2 concentration in solution
LOD confirmation	0.006 mmol/L
LOD H_2O_2 on mask	0.16 mg/mask for folded type and 0.25 mg/mask for cupped-type mask

Table S3: Reproducibility of hydrogen standard solutions from 0.006 mmol/L to 3.167 mmol/L (calibration included blank at 0 mmol/L)

Data#	Concentration range (mmol/L)	Slope	Intercept	RSQ
1	0.009-0.065	0.5322	-0.0084	0.9997
2	0.009-1.577	0.5283	-0.0060	1.0000
3	0.009-2.345	0.5337	-0.0059	1.0000
4	0.006-0.064	0.5137	-0.0208	0.9912
5	0.006-1.598	0.5298	-0.0051	1.0000
6	0.006-0.793	0.5331	-0.0073	1.0000
7	0.005-0.324	0.4773	-0.0070	1.0000
8	0.006-0.153	0.4751	-0.0090	0.9999
9	0.006-0.153	0.4910	-0.0027	0.9990
10	0.006-0.379	0.4755	0.0023	0.9979
11	0.006-3.088	0.4970	0.0044	0.9999
12	0.006-0.830	0.5078	-0.0033	0.9999
13	0.006-3.110	0.5026	0.0020	1.0000
14	0.006-3.167	0.4810	0.0011	0.9999
15	0.006-3.167	0.4754	0.0021	0.9999
16	0.006-0.316	0.5053	-0.0079	0.9998
17	0.006-1.484	0.5193	-0.0005	1.0000
18	0.015-0.765	0.5046	0.0041	0.9989
Mean		0.5046	-0.0038	0.9992
Standard deviation (S)		0.0218	0.0062	0.0021

t-statistic (0.05 probability at degree of freedom 17)	2.11	
tS	0.0459	0.0131
Mean ± tS	0.5046 ± 0.0459	-0.0038 ± 0.0131

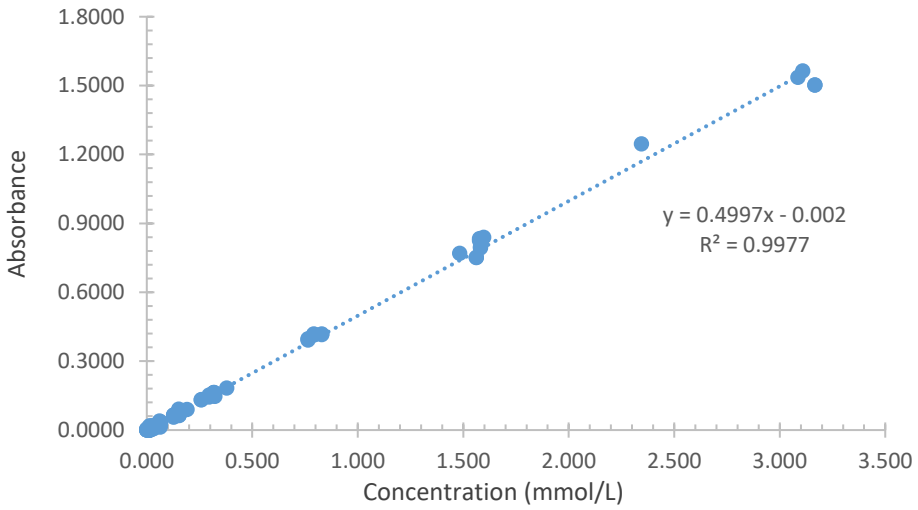

Figure S2: Linearity range of hydrogen peroxide solutions from 0.006 - 3.23 mmol/L

Table S4: Extraction procedure comparison

Test piece#	Handshake mask A1	End-over-end shaker mask A1	Handshake mask A2	End-over-end shaker mask A2
1	2.592	2.343	2.605	2.592
2	3.076	1.763	2.375	3.076
3	2.208	2.322	2.435	2.456
AV	2.626	2.143	2.472	2.708
RSD (%)	17	15	5	12

Table S5: One-way ANOVA Single factor of two extraction procedures

Anova: Single Factor mask-A1

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.3497	1	0.3497	2.3489	0.2001	7.7086
Within Groups	0.5954	4	0.1489			
Total	0.9451	5				

Anova: Single Factor mask-A2

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.0839	1	0.0839	1.3929	0.3033	7.7086
Within Groups	0.2408	4	0.0602			
Total	0.3247	5				

Table S6: Recovery (%) of the extraction and analysis of hydrogen peroxide on the respirator

Mask[a]#	mask-B	mask-D	mask-E	mask-F
1	98	97	80	102
2	100	105	104	99
3	98	95	102	95
Mean recovery ± s (%)	98.7 ± 1.0	99.0 ± 5.7	95.2 ± 13.1	98.5 ± 2.0
t-calculated[b]	2.2	0.3	0.6	1.3
t-calculated ≤ t-critical[c] of 4.3 at 95% CI	pass	pass	pass	pass
Conclusion from t-calculation	There is no difference between mean of recovery and spiked H_2O_2 from all masks at 95 % confidence interval.			
One-way ANOVA comparing the recovery results from all masks	There is no difference between the recovery results from all type of mask (0.91 of p-value ≥ 0.05 p-hypothesis).			
Overall mean recovery ± S_{pooled}[d]	98 % ± 7 %			
Standard uncertainty[e]	4 %			

[a] Recovery is calculated from $\frac{|Conc_{measured} - Conc_{surrogate}| \, x \, 100}{Conc_{surrogate}}$, when Conc is concentration of hydrogen peroxide

[b] Significant test between recovery and spiked value, $t - calculated = \frac{Absolute(100 - \%\, recovery)}{s/\sqrt{n}}$

[c] t-critical is calculated from MS Excel software (=T.INV.2T(0.05,2)) at probability 0.05 and degree of freedom 2

[d] S_{pooled} is calculated from $\sqrt{\frac{\sum(s_i^2 \, x \, (n_i - 1))}{\sum(n_i - 1)}}$, when s is standard deviation of mask (i)

[e] Standard uncertainty is standard deviation of mean from method recovery is calculated from $RSD_{pooled} \, /\sqrt{N}$ when N is from 4 types of mask

Table S7: Quantification of uncertainty for the determination of hydrogen peroxide on N95 mask [1]

Identify sources of uncertainty	unit	Value	Standard deviation	Standard deviation description	Distribution data	Standard uncertainty (u_s)[a]	Relative standard uncertainty (u_r)[b]	u_r^2	u (%)
Mask wt	g	10	0.0025	Lab precision	1	0.00250	0.00025	0.00000	0.2
Test piece wt	g	0.1	0.0003	Lab precision	1	0.00030	0.00300	0.00001	2.8
Extract volume	mL	10	0.0046	Lab precision	1	0.00459	0.00046	0.00000	0.4
Test volume	mL	5	0.0018	Lab precision	1	0.00184	0.00037	0.00000	0.3
Atomic mass of hydrogen		1.00794	0.0000	[1]	√3	0.000016	0.00002	0.00000	0.0
Atomic mass of oxygen		15.9994	0.0001	[1]	√3	0.000071	0.000004	0.00000	0.0
H_2O_2 standardization	mmol/L	30	0.3396	standard deviation of mean S/√ n, n=3[c]	√3	0.196060	0.00611	0.00004	6
UV-Vis linearity of calibration graph	mmol/L	0.3098	0.0028[d]	lab data	1	0.00277	0.00893	0.00008	8
Method[e]	%	97.9	7.2	standard deviation of mean RSD/√ N, N=4	√4	3.6	0.03689	0.00136	34
Precision within-mask[f]	%	100	7.3	standard deviation of mean (RSD/√ n, n=replicated analysis (2))	√2	5.2	0.05162	0.00266	48
Combined relative uncertainty (Σu_r^2)								0.0042	
Relative uncertainty ($u_r = \sqrt{\Sigma u_r^2}$)								0.064	
Expanded uncertainty (U) = ku x c (k is coverage facter of 2), c is H_2O_2 concentration on mask = 11.5 mg								1.48	
%U								13	
Concentration of hydrogen peroxide 11.5 ± 1.5 mg/mask									

[a] Standard uncertainty $(u_s) = \frac{s}{distribution}$

Where s is standard deviation from laboratory experiment or method validation data or literature or certificate

[b] Relative standard uncertainty $(u_r) = \frac{u_s}{value}$

[c] Standard deviation of mean is calculated from $S_{pooled} / \sqrt{n}$

When n is the replicated analysis of titration

[d] Uncertainty from linearity of calibration graph $u_{cal\ graph} = \frac{s_E}{slope} x \sqrt{\frac{1}{p} + \frac{1}{n} + \frac{(c_o + \bar{c})^2}{S_{xx}}}$

Where S_E is standard error of slope, n is a number of replication per mask, p is a number of data point of standard solutions

c_o is the concentration (mmol/L) of mask

$\bar{c}$ is the mean of hydrogen peroxide standard solution concentration

$$S_{xx} = \sum_{i}^{j} (c_i - \bar{c})^2$$

Where c_i is the concentration of hydrogen peroxide standard solution (i)

Calculate the uncertainty from H_2O_2 calibration graph

Concentration (mmol/L)	Abs	$(c_i - \bar{c})^2$
0	0.0000	0.1103
0.006	0.0001	0.1061
0.016	0.0058	0.1000
0.032	0.0148	0.0902
0.064	0.0322	0.0716
0.161	0.0845	0.0293
0.319	0.1680	0.0002
0.793	0.4228	0.2121
1.598	0.8429	1.6017
$\bar{c}$	0.3320	

u calibration graph	value	$u_{cal\ graph} = \frac{s_E}{slope} x \sqrt{\frac{1}{p} + \frac{1}{n} + \frac{(c_o + \bar{c})^2}{S_{xx}}}$	Value
Standard error of slope	0.0014	$\frac{S_E}{slope}$	0.003
slope	0.5298		
p (replcate)	1	1/p	1.000
n (calration points)	9	1/n	0.111
C_0 (Abs of sample)	0.31	$(c_o + \bar{c})^2$	0.0005
$\bar{c}$	0.332		
S_{xx}	2.3214	$S_{xx} = \sum_{i}^{j} (c_i - \bar{c})^2$	2.3214
$u_{cal\ graph}$	0.0028		

[e] Standard uncertainty is a standard deviation of mean from method recovery, and calculated from $RSD_{pooled} / \sqrt{N}$, where N is 4 (types of mask)

[f] Standard uncertainty is the standard deviation of mean from routine ananlysis, and calculated from $RSD_{pooled} / \sqrt{n}$, where n is 2 (duplicate analysis per mask)

[1] S.L.R. Ellison, A. Williams, eds., Eurachem / CITAC Guide: Quantifying Uncertainty in Analytical Measurement, Third edition, Eurachem, 2012. https://www.eurachem.org/images/stories/Guides/pdf/QUAM2012_P1.pdf.