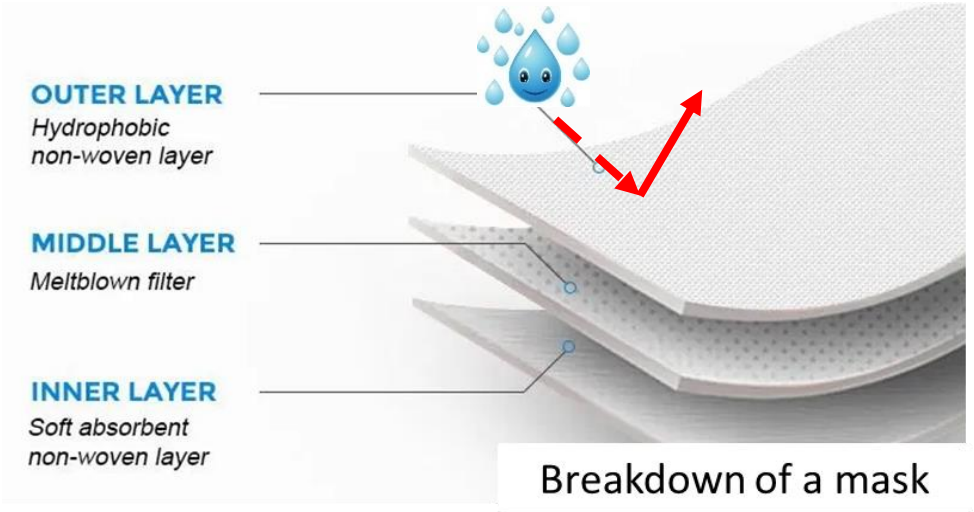
Agency for Science, Technology and Research
SINGAPORE

THE SCIENCE BEHIND A DIY REUSABLE MASK USING HOUSEHOLD MATERIALS

5 April 2020

Background: Basic make-up of a surgical mask



Breakdown of a mask

1. Outer layer: **Waterproof** to repel water droplets from nose and face
2. Middle layer: Meltblown filter with thinner fibres to **remove particulates**
3. Inner layer: Soft **absorbent layer** to absorb saliva and liquids from mouth

DIY Reusable Mask Design

Outer hydrophobic layer (reusable + washable)

- Reusable non-woven bags (e.g. supermarket totes)
- **Important to test under running water to check if waterproof*

Middle filtering layer (disposable)

- Dried hypoallergenic wet wipe or baby wipe

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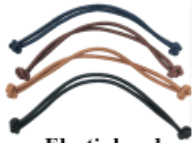
DIY Reusable Mask Design

Inner absorbent layer (reusable + washable)

- Thin cotton cloth (from t-shirts, wiping cloth)

Other tools and components

- Elastic band, rubber band (to strap to head) (reusable + washable)



- Cable tie (for nose bridge) (reusable + washable)

- Staples and masking/duct tape (to affix everything together)

DIY Mask – Testing (Basic Parameters)

- Testing conducted on DIY mask: bacterial filtration (BFE), particle filtration (PFE) and pressure drop

  - ✓ **Bacterial Filtration Efficiency** (BFE) measures the filtration efficiency of masks using live bacteria (viable particles)-containing droplets that vary in size from 1 to 5 microns.

  - ✓ **Particle Filtration Efficiency** (PFE) measures the filtration efficiency of a mask using non-living, or nonviable particles that are fixed in size from 0.1 micron to 1 micron. The higher the PFE, the more protection the wearer has against airborne particles.

  - ✓ **Pressure Drop** measures the air flow resistance of the mask and is an objective measure of breathability. The higher the value, the harder it is for the wearer to breathe.

DIY Mask – Testing (Results)

- The DIY mask has comparable essential properties as a surgical mask.
- The table shows the comparison of essential properties between a surgical mask and the DIY mask.

Test	European Standard for Medical Face Masks	Surgical Mask	ASTAR DIY Mask
Can it filter? Bacterial Filtration Efficiency (%)	≥ 95	≥ 95	**≥ 95**
Can I breathe? Pressure drop (Pa/cm^2) Delta P	< 29.4	0.5-1.3	**4-27** *(depending on the materials used*
Additional test for filtering very small particles (more for dust particles)			
PFE (0.1μm) (%)	Nil	79-82	**70-85**

DIY Mask – Testing (Third Party)

TEST REPORT: 7191232254-CHM20-02-RC
28 FEB 2020

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RESULTS

Sample Description : IBN DIY Mask

Test sample/ controls	Stage 1, CFU	Stage 2, CFU	Stage 3, CFU	Stage 4, CFU	Stage 5, CFU	Stage 6, CFU	Sum of Total plate count for the 6 sieves, CFU	Average Count for Controls, CFU	BFE (%)	Average BFE (%)
-ve Control Before	0	0	0	0	0	0	0	0		
-ve Control After	0	0	0	0	0	0	0			
+ve Control 1	134	241	557	385	301	154	1772	1725		
+ve Control 2	101	435	401	361	308	150	1756			
+ve Control 3	146	280	419	364	295	143	1647			
Sample 1	0	0	0	0	12	77	89		94.84	95.48
Sample 2	0	0	0	0	5	68	73		95.77	
Sample 3	0	0	0	1	8	67	76		95.59	

Third party tester TUV-SUD testing results for DIY mask

TEST REPORT: 7191232254-CHM20-02-RC

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Note: This report is issued subject to the Testing and Certification Regulations of the TÜV SÜD Group and the General Terms and Conditions of Business of TÜV SÜD PSB Pte Ltd. In addition, this report is governed by the terms set out within this report.

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SUBJECT

Bacterial Filtration Efficiency (BFE)

CLIENT

Advanced Remanufacturing and Technology Centre
3 CleanTech Loop
#01-01 CleanTech Two
Singapore 637143

Attn :

SAMPLE SUBMISSION DATE / TEST DATE

21 Feb 2020 / 25 Feb 2020

DESCRIPTION OF SAMPLE

One sample of face mask labelled as "IBN DIY Mask" was submitted by the above company.

METHOD OF TEST

ASTM F2101-19 Standard Test Method for Evaluating the Bacterial Filtration Efficiency (BFE) of Medical Face Mask Materials, Using a Biological Aerosol of Staphylococcus aureus.

Area contacting with the bacterial challenge: External of the mask
Flowrate: 28.3 ± 0.3 L/min
Mean particle size of the challenge aerosol: 3 µm ± 0.3 µm
Test area: Approximately 38.5 cm^2

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Reusing DIY Masks – Disinfection Methods

The table below shows the BFE values of the DIY mask, before and after subjecting it to different disinfection methods. The BFE values are between 70-95%, depending on the materials used.

Test	Before washing	After boiling*	After microwaving**	After washing + sunning ***
Can it still filter? Bacterial Filtration Efficiency (%)	≥ 95	≤ 70	≥ 95	≥ 95
Disinfection methods: *(Note: middle filter layer should be taken out and disposed, and then replaced with a new layer after disinfecting the inner and outer layers.* **)**				
*Boiling	5 mins boiling for each re-use			
**Microwave	Place in microwave for 5 min			
***Washing + sunning	Washing under liquid soap and place under sun for 2h			

Note: mask performance could also vary depending on the materials used and how it is assembled.

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Note: This DIY reusable mask is not a surgical mask. Users should continue to observe personal hygiene and wash hands regularly with soap and water, and practice safe distancing measures.