NAMI functional coating on paper

Grace Poon

13 Jan 2023

Background of Invention

In food industry, Per/polyfluoroalkyl substances (PFAS) are mixed with paper pulp or coated on paper packaging to improve the water and oil resistance for temporary storage of food.

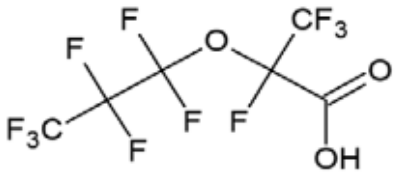
However, Per/polyfluoroalkyl substances (PFAS) can cause reproductive and developmental, liver and kidney, and immunological effects in laboratory animals.

Examples of PFAS Chemicals

Small Molecules

$C_nF_{2n+1}R$

PFOS, R = SO_3H, n = 8
PFOA, R = COOH, n = 7

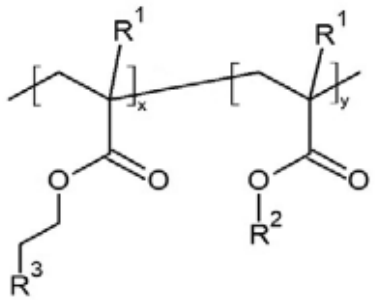


"GenX"

Polymers

$-(CF_2CF_2)_n-$

PTFE, "Teflon"



Acrylate-containing PFAS

R^1 = -H, $-CH_3$
R^2 = alkyl group
R^3 = poly- or perfluorinated alkyl group

FIGURE 1 Chemical structure of selected PFAS

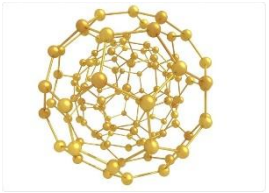
PFAS: Per/polyfluoroalkyl substances

PFOS: Perfluorooctane sulfonic acid
PFOA: Perfluorooctanoic acid
PTFE: Polytetrafluoroethylene

Issues with some PFAS
- Toxic
- Bioaccumulation (refers to the buildup of persistent chemical substances in the body)
- Non-biodegradable

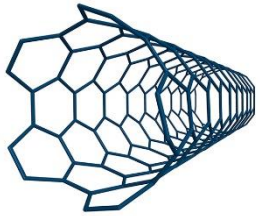
What is NAMI Nano-shield Coating Made of?

- The functional coating is made of Nanocomposite materials.
- Nanocomposite material refers to composites in which at least one solid phase has nanoscale morphology such as nanoparticle, nanotube, nanocrystal or lamellar nanostructure



Nanoparticle

Nanocrystal

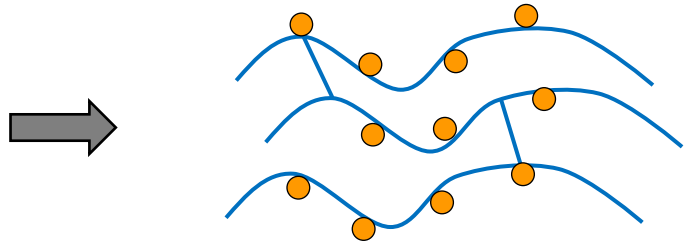


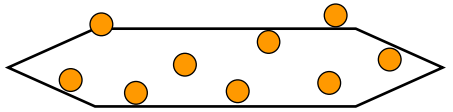
Nanotube

Polymer based material

OR

Non-polymer based material





Nanocomposite Material

NAMI Nano-shield Coating on Paper

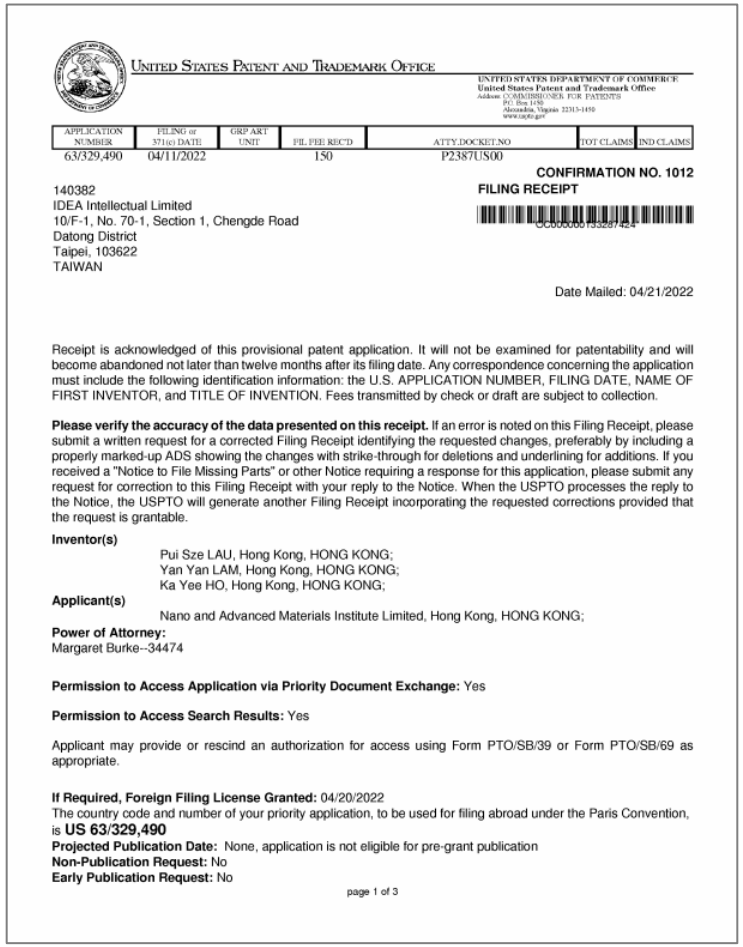
NAMI Nano-shield Coating -- Merits

Table 1: Comparison of NAMI Nano-shield Coating to traditional shielding material (PFAS[1])

Property & Performance	PFAS	NAMI Nano-shield Coating
Water resistance (ISO 535, water absorptiveness – Cobb method[2], g/m^2)	< 20	<1
Grease/oil resistance (TAPPI T-559 KIT TEST[3])	> 7	12
Fluorine free	X	√
Biodegradable	X	√
Dry weight amount on paper (g/m^2)	3-10	10-30

[1] PFAS: Per/Polyfluoroalkyl substances
[2] Cobb: number smaller, water resistance better
[3] TAPPI T-559 KIT TEST: Kit no. 1 -12, higher the 'Kit' value, the higher the resistance to grease/oil

NAMI Nano-shield Coating -- US Patent & FDA Testing



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
63/329,490	04/11/2022		150	P2387US00		

CONFIRMATION NO. 1012

FILING RECEIPT

140382
IDEA Intellectual Limited
10/F-1, No. 70-1, Section 1, Chengde Road
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Taipei, 103622
TAIWAN

Date Mailed: 04/21/2022

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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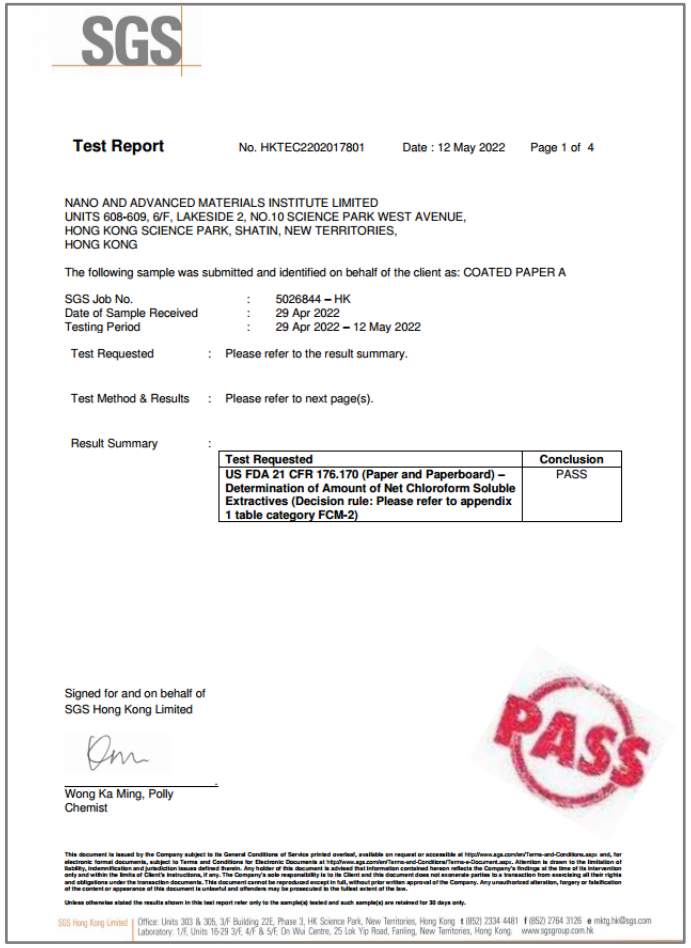
Early Publication Request: No

page 1 of 3



SGS

Test Report No. HKTEC2202017801 Date : 12 May 2022 Page 1 of 4

NANO AND ADVANCED MATERIALS INSTITUTE LIMITED
UNITS 608-609, 6/F, LAKESIDE 2, NO.10 SCIENCE PARK WEST AVENUE,
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HONG KONG

The following sample was submitted and identified on behalf of the client as: COATED PAPER A

SGS Job No. : 5026844 – HK
Date of Sample Received : 29 Apr 2022
Testing Period : 29 Apr 2022 – 12 May 2022

Test Requested : Please refer to the result summary.

Test Method & Results : Please refer to next page(s).

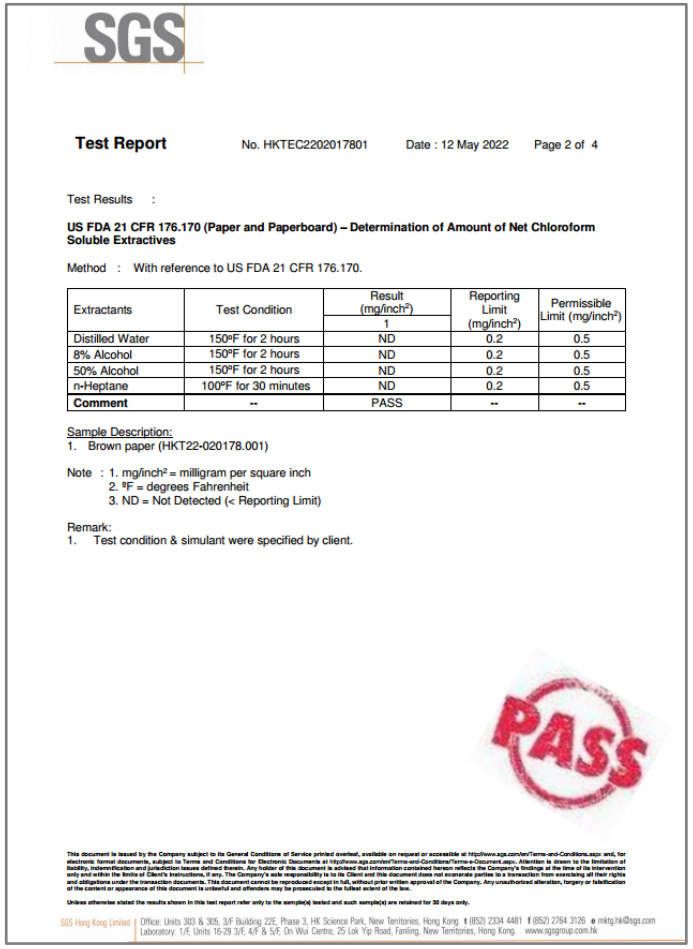
Result Summary :

Test Requested	Conclusion
US FDA 21 CFR 176.170 (Paper and Paperboard) – Determination of Amount of Net Chloroform Soluble Extractives (Decision rule: Please refer to appendix 1 table category FCM-2)	PASS

Signed for and on behalf of
SGS Hong Kong Limited

Wong Ka Ming, Polly
Chemist

PASS



SGS

Test Report No. HKTEC2202017801 Date : 12 May 2022 Page 2 of 4

Test Results :

US FDA 21 CFR 176.170 (Paper and Paperboard) – Determination of Amount of Net Chloroform Soluble Extractives

Method : With reference to US FDA 21 CFR 176.170.

Extractants	Test Condition	Result (mg/inch²)	Reporting Limit (mg/inch²)	Permissible Limit (mg/inch²)
		1		
Distilled Water	150°F for 2 hours	ND	0.2	0.5
8% Alcohol	150°F for 2 hours	ND	0.2	0.5
50% Alcohol	150°F for 2 hours	ND	0.2	0.5
n-Heptane	100°F for 30 minutes	ND	0.2	0.5
Comment	--	PASS	--	--

Sample Description:
1. Brown paper (HKT22-020178.001)

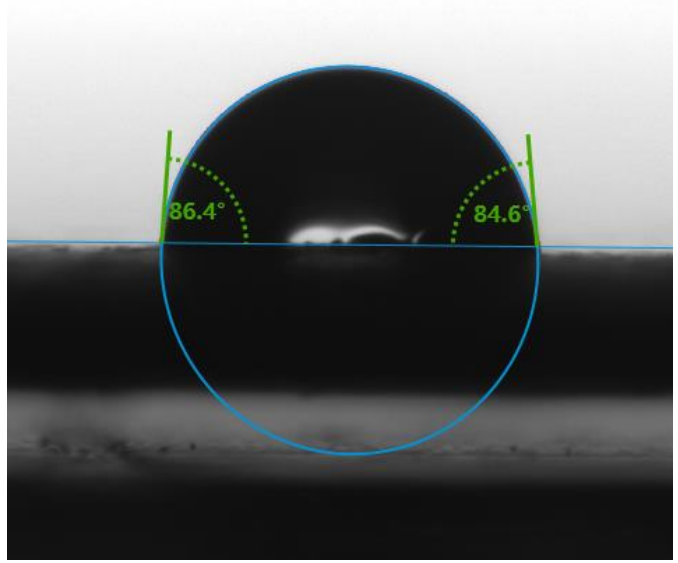
Note : 1. mg/inch² = milligram per square inch
2. °F = degrees Fahrenheit
3. ND = Not Detected (< Reporting Limit)

Remark:
1. Test condition & simulant were specified by client.

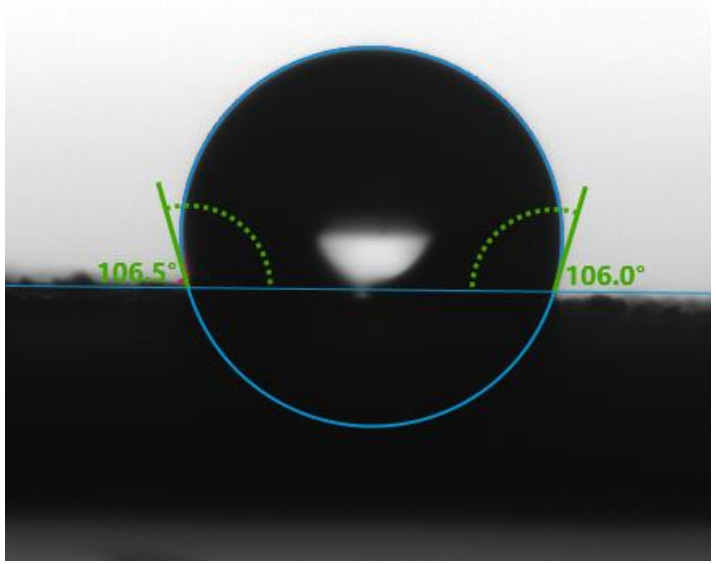
PASS

NAMI Nano-shield Coating on Paper - Hydrophobicity

(a)



(b)



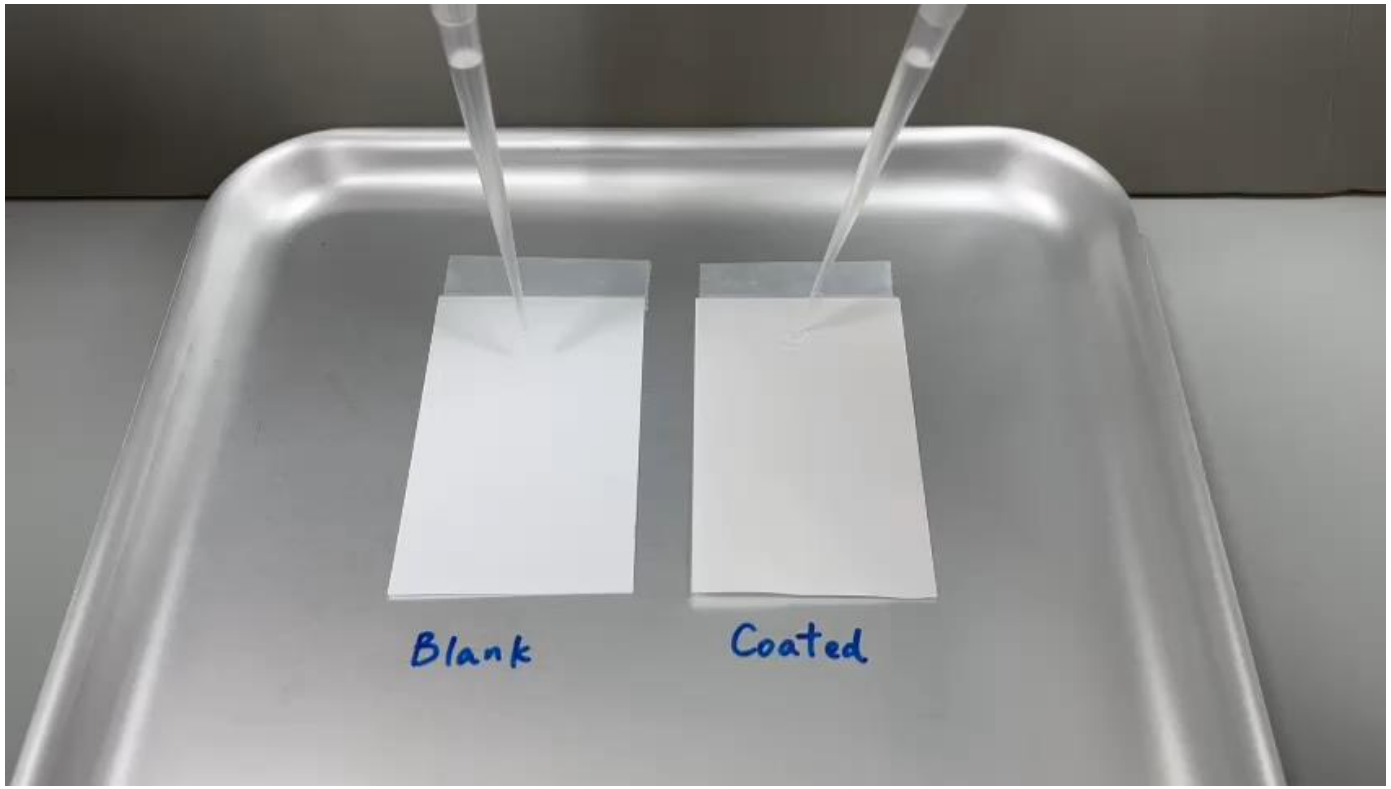
Water contact angle of (a) blank 300 g/m^2 brown cardboard paper and (b) 300 g/m^2 brown cardboard paper with nano-shield coating.

NAMI Nano-shield Coating on Paper - Water Resistance

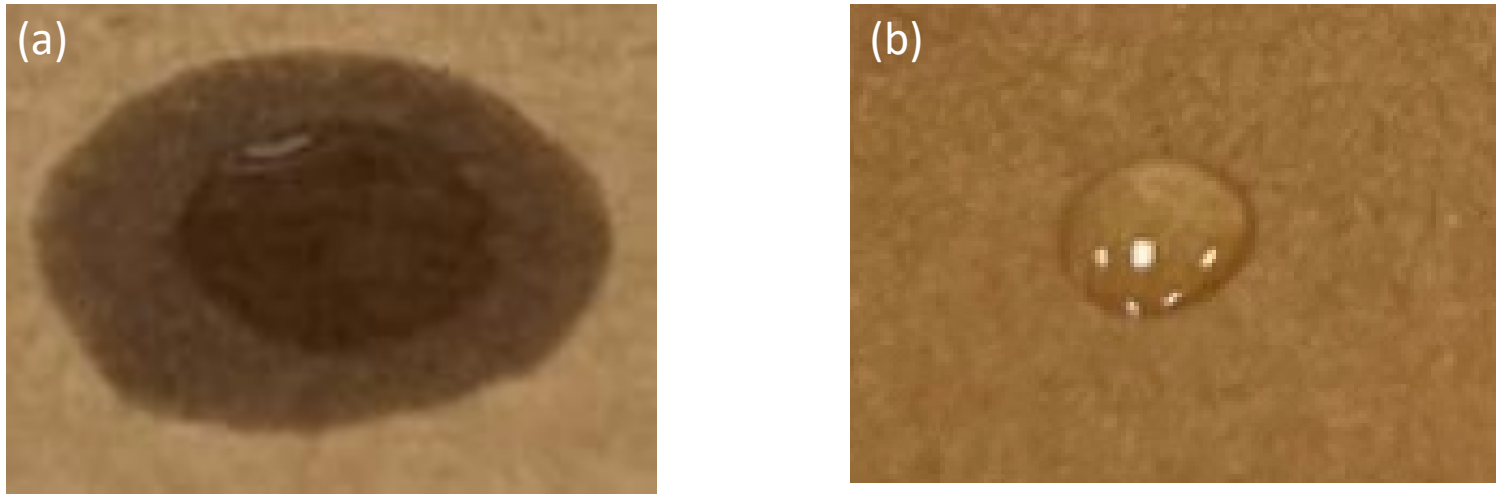
ISO 535/ TAPPI T 441

Paper and board – Determination of water absorptiveness -- Cobb test

Sample	Cobb60 (g/m^2)
120 g blank paper	29
NAMI coated paper	0



NAMI Nano-shield Coating on Paper - Oleophobicity

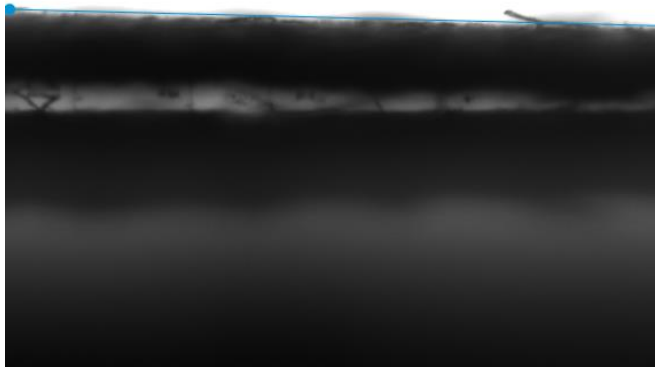


Peanut oil droplet on (a) blank 300 g/m^2 brown cardboard paper and (b) 300 g/m^2 brown cardboard paper with nano-shield coating.

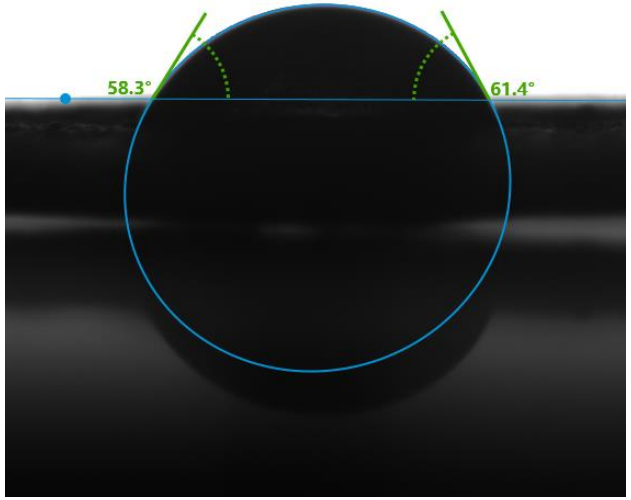
NAMI Nano-shield Coating on Paper - Oleophobicity

(a)

Peanut oil was absorbed



(b)



Peanut oil contact angle on (a) blank 300 g/m^2 brown cardboard paper and (b) 300 g/m^2 brown cardboard paper with nano-shield coating.

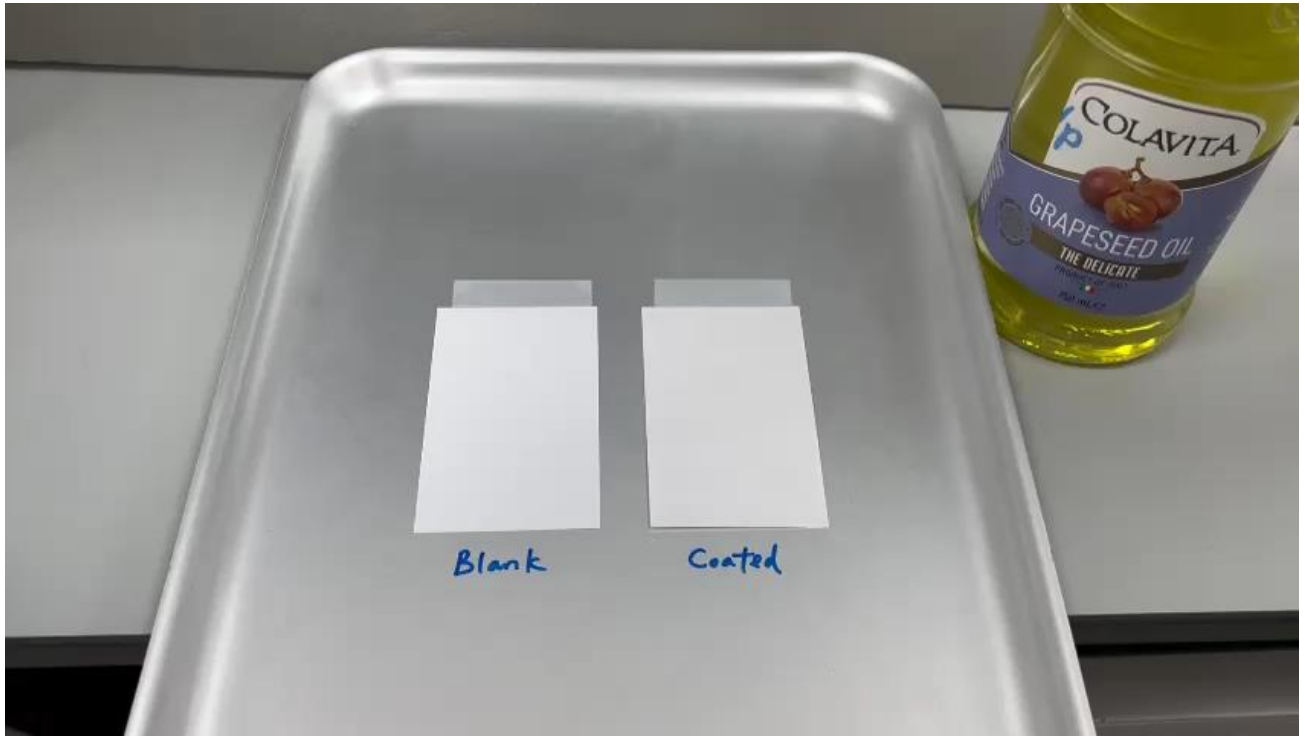
NAMI Nano-shield Coating on Paper -- Oil Resistance

TAPPI T 559 / T 559 cm-02

Grease resistance test for paper and paperboard – Kit test

Kit solutions: castor oil, toluene & n-heptane

Sample	Kit value
120 g blank paper	<1
NAMI coated paper	12



NAMI Nano-shield Coating on Paper – Test on WVTR

Water vapor transmission rate (WVTR)

- ASTM E96
- Water method
- Temperature: 38°C
- Humidity: 10% RH
- Testing area: 32.95 cm^2

Sample	WVTR (g/(m^2·day))	% reduction
Plain 120 g brown paper	3,210.4 ± 9.7	-
NAMI-paper sample	1,159.8 ± 3.4	63.9%

Preliminary test shows paper with NAMI nanocomposite coating can reduce WVTR by ~64%.

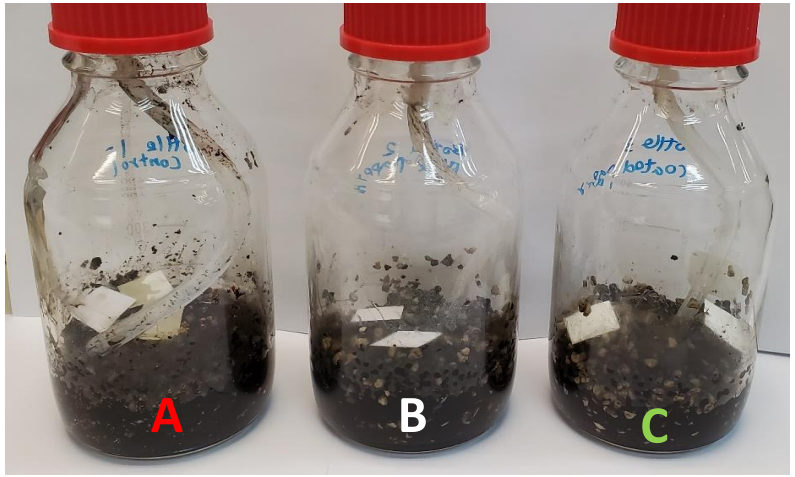
NAMI Nano-shield Coating on Paper – Aerobic Biodegradability

Aerobic Biodegradation
-- ASTM D5338/D6868

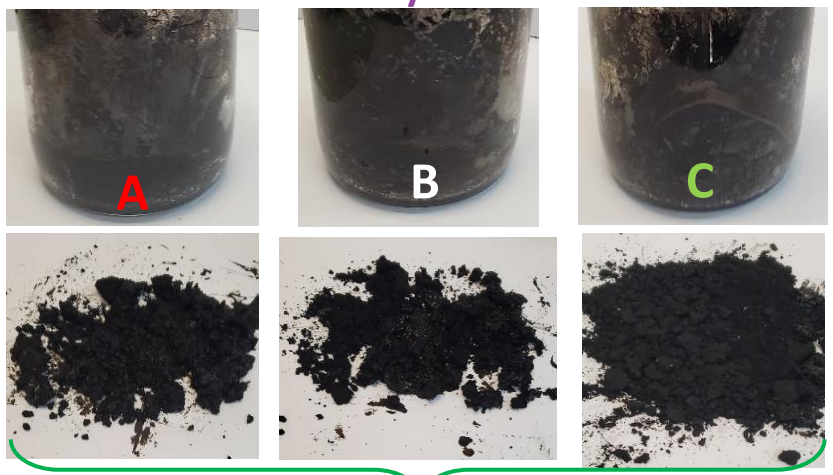
Test sample (100 g / bottle)

- A: Control (sterilized compost + blank paper + coated paper)
- B: Blank (compost + uncoated paper)
- C: NAMI sample (compost + coated paper)

Day 0



Day 67



Paper was not observed after 67 days !

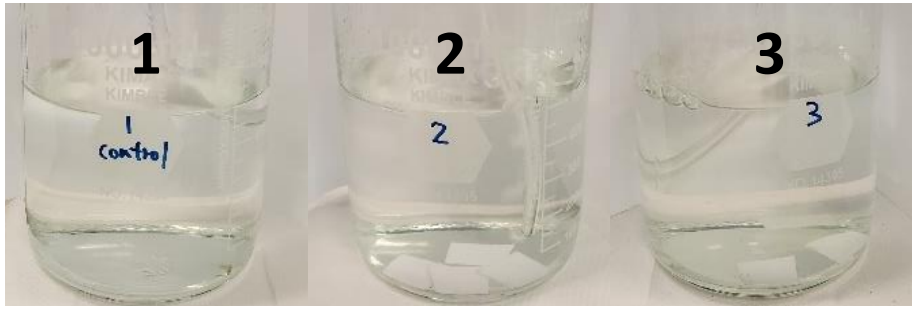
NAMI Nano-shield Coating on Paper – Seawater Biodegradability

Seawater Biodegradation
-- ASTM D6691

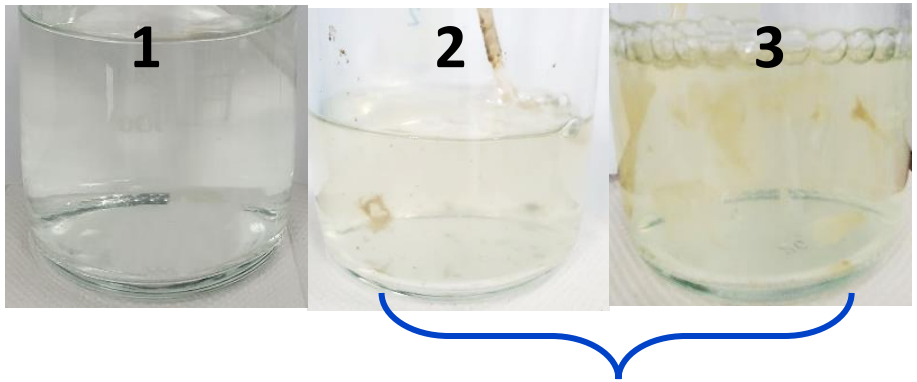
Test sample

- Bottle 1: Control (seawater only)
- Bottle 2: Blank (seawater + uncoated paper)
- Bottle 3: NAMI sample (seawater + coated paper)

Day 0

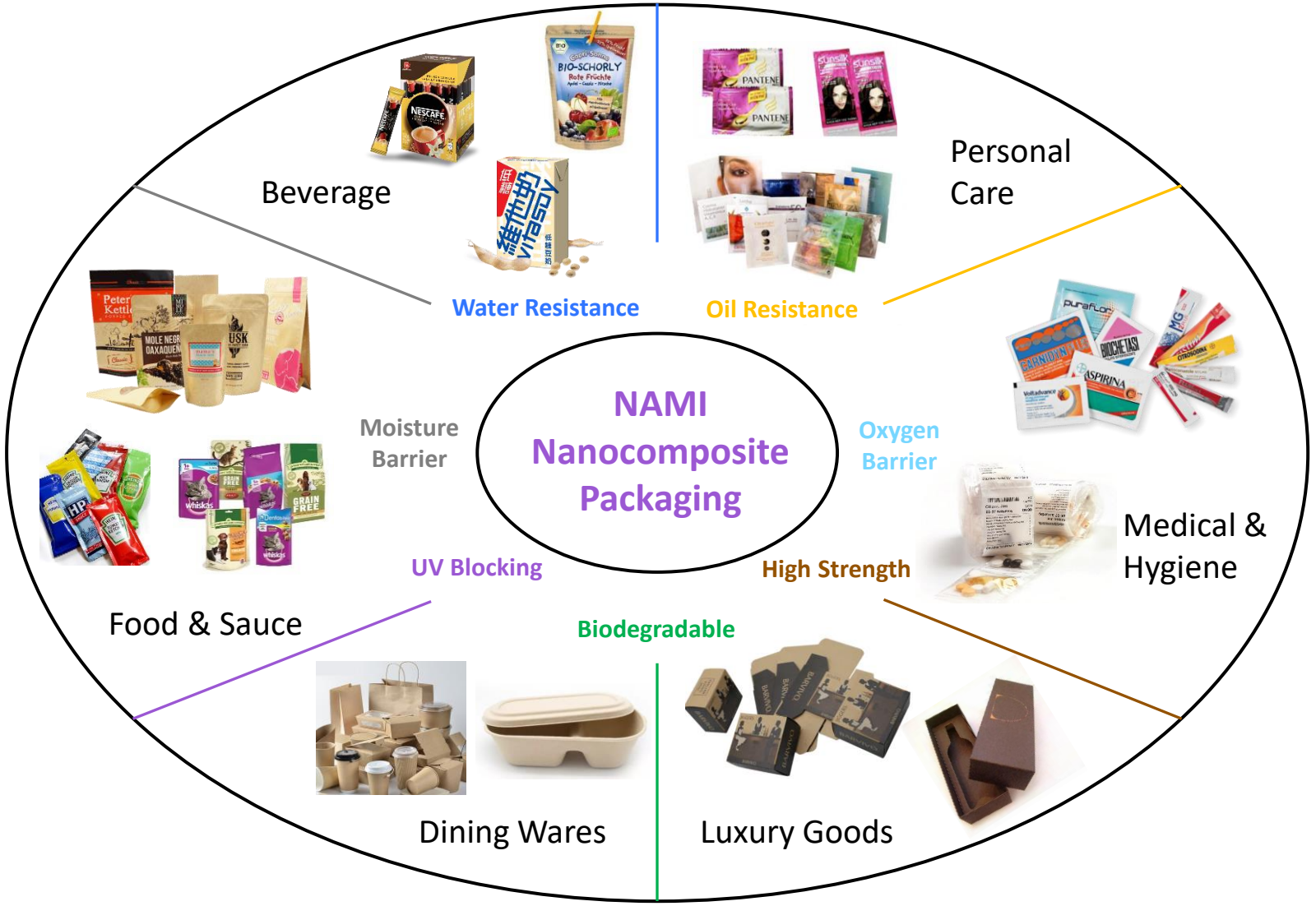


Day 105



The size of paper was greatly reduced!

Future Applications



Hong Kong Re-industrialization

Other Potential Applications are Welcome