Supplementary Information

Amphiphobic Nanocellulose-modified Paper: Fabrication and Evaluation

Patchiya Phanthong [1], Guoqing Guan [1, 2*], Surachai Karnjanakom[1], Xiaogang Hao [3], Zhongde Wang[3], Katsuki Kusakabe[4], Abuliti Abudula [1, 2]

[1]*Graduate School of Science and Technology, Hirosaki University, 1-Bunkyocho, Hirosaki 036-8560, Japan*

[2]*North Japan Research Institute for Sustainable Energy (NJRISE), Hirosaki University, 2-1-3, Matsubara, Aomori 030-0813, Japan*

[3] *Department of Chemical Engineering, Taiyuan University of Technology, Taiyuan 030024, China*

[4] *Department of Nanoscience, Sojo University, 4-22-1 Ikeda, Nishi-ku, Kumamoto 860-0082, Japan*

[*]Corresponding author. Tel.: +81-17-762-7756; Fax: +81-17-735-5411.

E-mail address: guan@hirosaki-u.ac.jp (G. Guan)

Table S-1 Contact angles of various liquids on FOTS treated and untreated nanocellulose-modified PTFE filter papers.

Sample	Average contact angle (°)			
	water	n-hexane	n-octane	n-hexadecane
PTFE	44	0	0	0
FOTS treated for 1 h	143	37	64	102
FOTS treated for 5 h	147	36	55	100
FOTS treated for 9 h	141	26	48	83
0.01 wt% nanocellulose/PTFE	47	0	0	27
FOTS treated for 1 h	135	15	0	94
FOTS treated for 5 h	148	0	0	99
FOTS treated for 9 h	134	50	61	104
0.1 wt% nanocellulose/PTFE	52	0	0	20
FOTS treated for 1 h	146	29	55	107
FOTS treated for 5 h	153	26	43	92
FOTS treated for 9 h	149	34	61	108
0.5 wt% nanocellulose/PTFE	52	0	0	15
FOTS treated for 1 h	151	33	56	108
FOTS treated for 5 h	151	29	51	98
FOTS treated for 9 h	142	36	59	100

Table S-2 Contact angles of various liquids on FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper.

Liquid	Average contact angle (°)
Seawater	148
Sodium chloride solution (5 wt%)	151
Distilled water (7 ºC)	145
Distilled water (50 ºC)	149
Sulfuric acid solution (pH = 1)	151
Sodium hydroxide solution (pH = 14)	142
Toluene	86
Ethylene glycol	121
Formamide	135
Vacuum pump oil	88

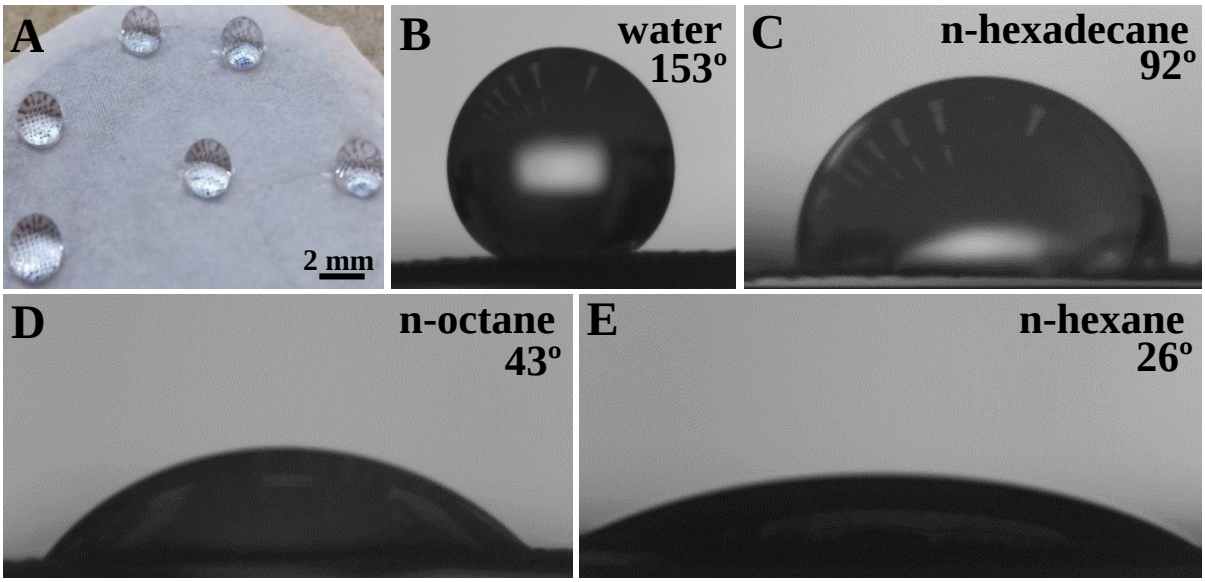

Fig.S-1 Liquid droplets on the amphiphobic surface of FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper. A: water droplets in marble shape; B: water; C: n-hexadecane; D: n-octane; E: n-hexane.

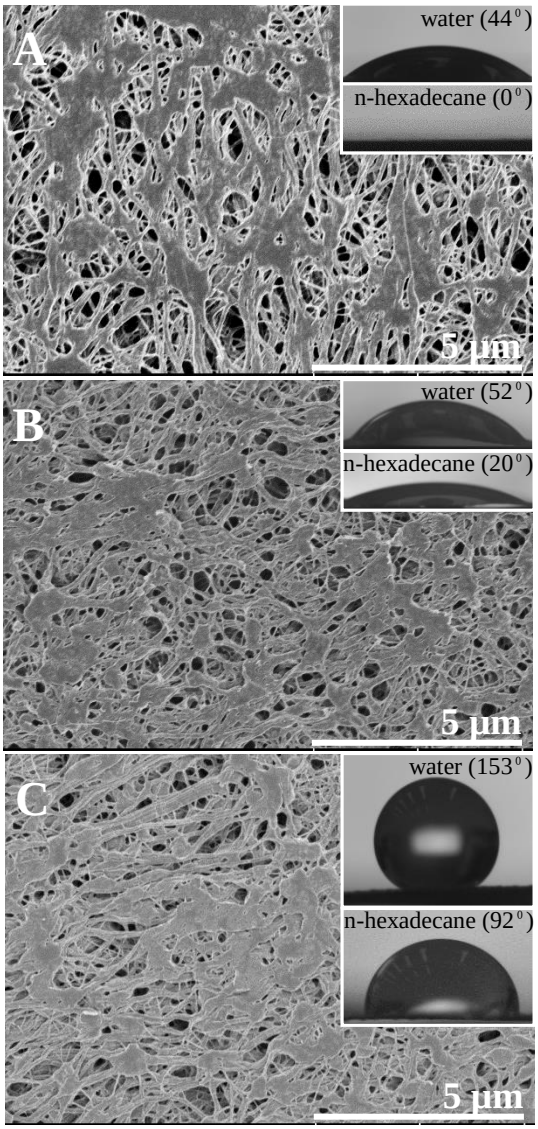

Fig.S-2 SEM images of A: PTFE filter paper ; B: 0.1wt% nanocellulose-modified PTFE filter paper; C: FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper. Insets: contact angles of water and n-hexadecane.

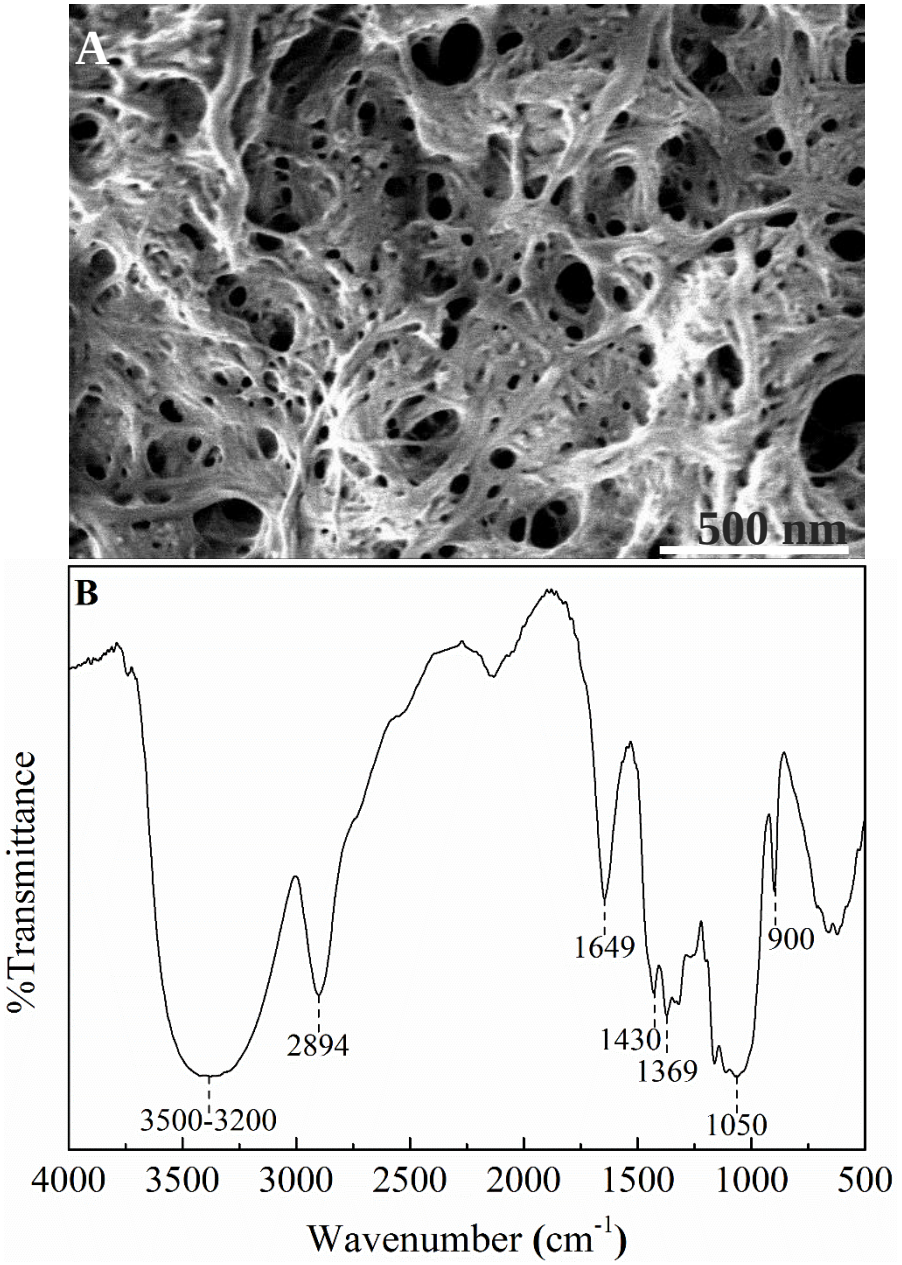

Fig.S-3 SEM image of nanocellulose (A) and its FT-IR spectrum (B).

Fig.S-3 shows SEM image of nanocellulose used in this study (A) and FT-IR spectrum of it. The absorption peaks at around 3500-3200, 2894, 1649, 1430, 1369, 1050, and 900 cm^{-1} are similar to the chemical compositions to the native cellulose type I. The broad peak at around 3500-3200 cm^{-1} is attributed to the stretching of O-H groups. The absorption peak at around 2894 cm^{-1}

indicates the CH_2 groups of nanocellulose while the peak around 1649 cm^{-1} is associated with the O-H bond of water absorption by nanocellulose. The absorption peak appearing at 1430 cm^{-1} is related to CH_2 bending of the intermolecular hydrogen attraction at the C_6 group. The absorption peak at 1369 cm^{-1} corresponds to the asymmetric stretching of C-H groups of polysaccharides, while the peak appearing at 1050 cm^{-1} is the C-O stretching and C-H vibration in nanocellulose. The detected peak at 900 cm^{-1} is associated with the C-H rocking vibration of β-glycosidic linkages between glucose units in nanocellulose.[1-2]

[1] M. K. M. Haafiz, A. Hassan, Z. Zakaria and I. M. Inuwa, *Carbohydr. Polym.*, 2014, **103**, 119-125.

[2] N. Johar, I. Ahmad and A. Dufresne, *Ind. Crop. Prod.*, 2012, **37**, 93-99.

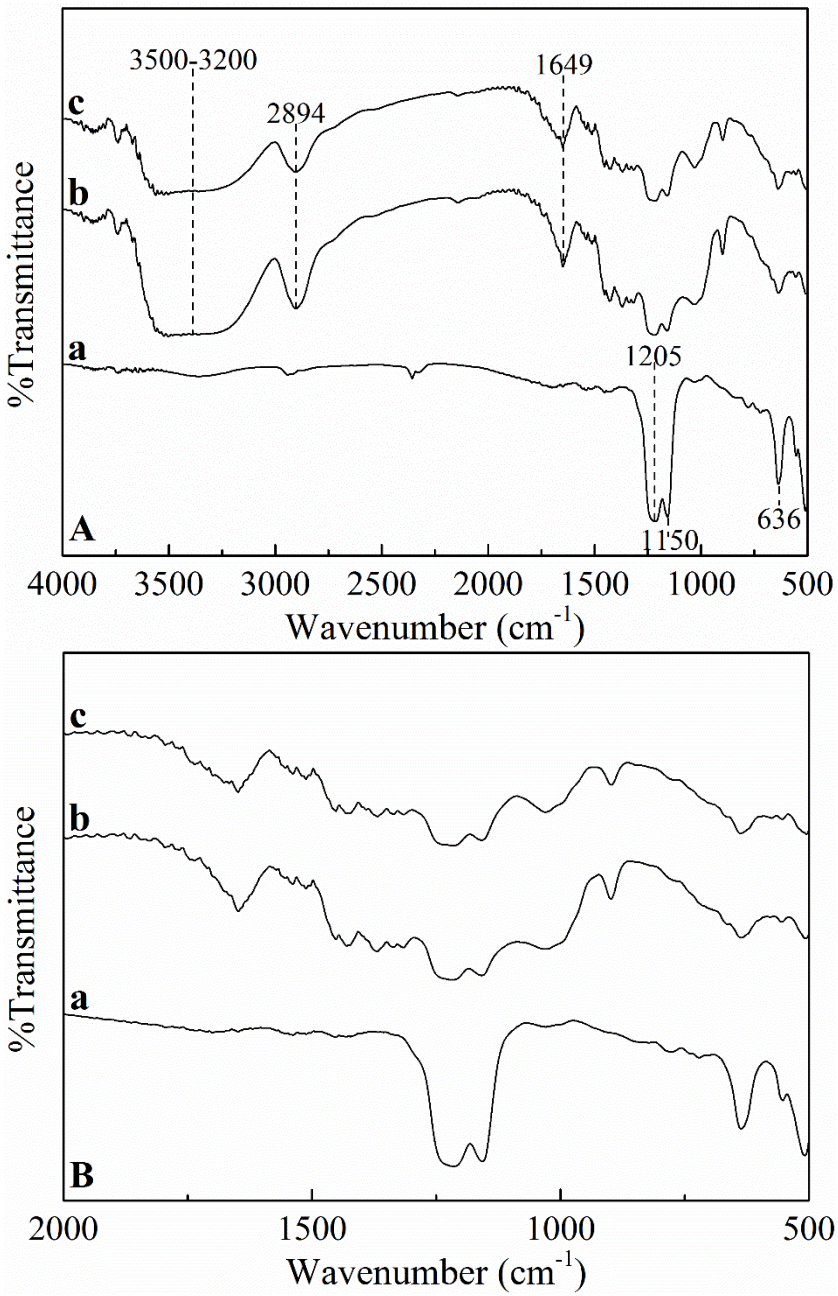

Fig.S-4 A: FT-IR spectra of (a) PTFE filter paper, (b) 0.1wt% nanocellulose-modified PTFE filter paper, and (c) FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper; B: Enlargement between 500-2000 cm^{-1}.

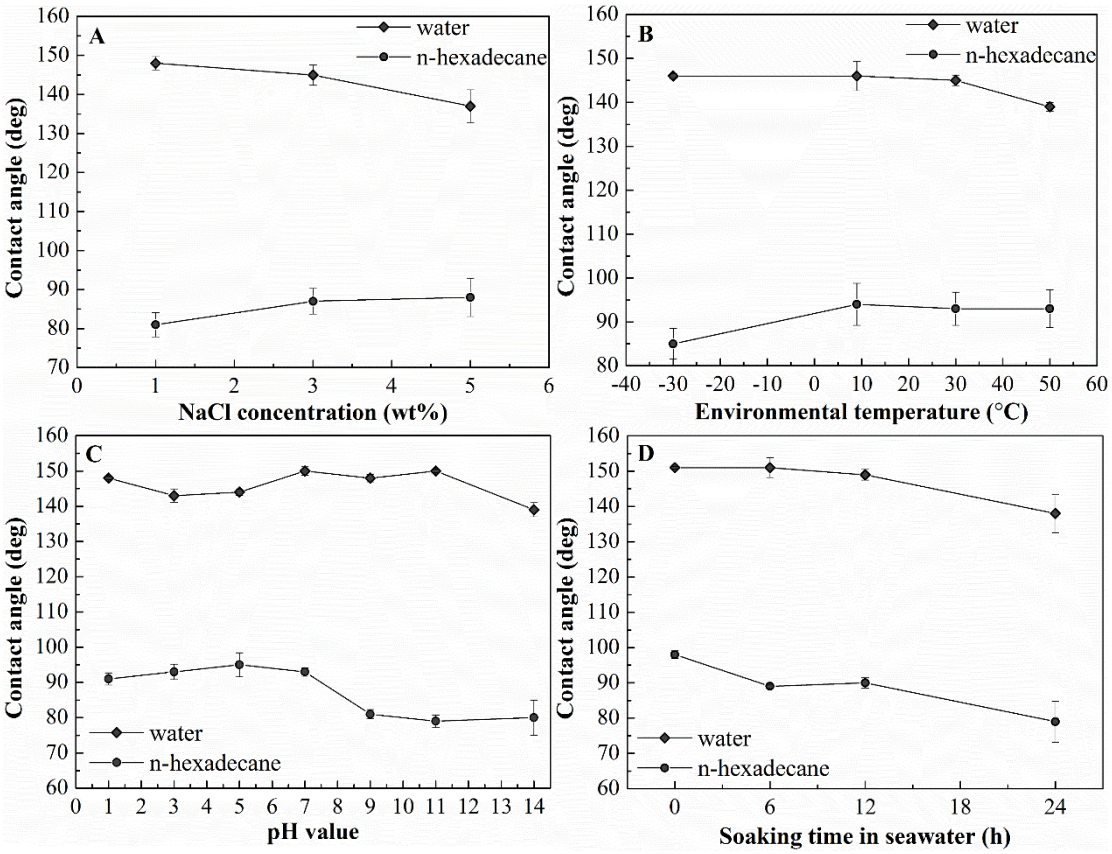

Fig.S-5 Durability of the contact angles of water and n-hexadecane on the amphiphobic surface of FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper in various environments.

A: soaking in various NaCl solutions for 6 h ; B: various environmental temperatures ; C: soaking in various solutions with different pH values ; D: soaking in real seawater for different periods.

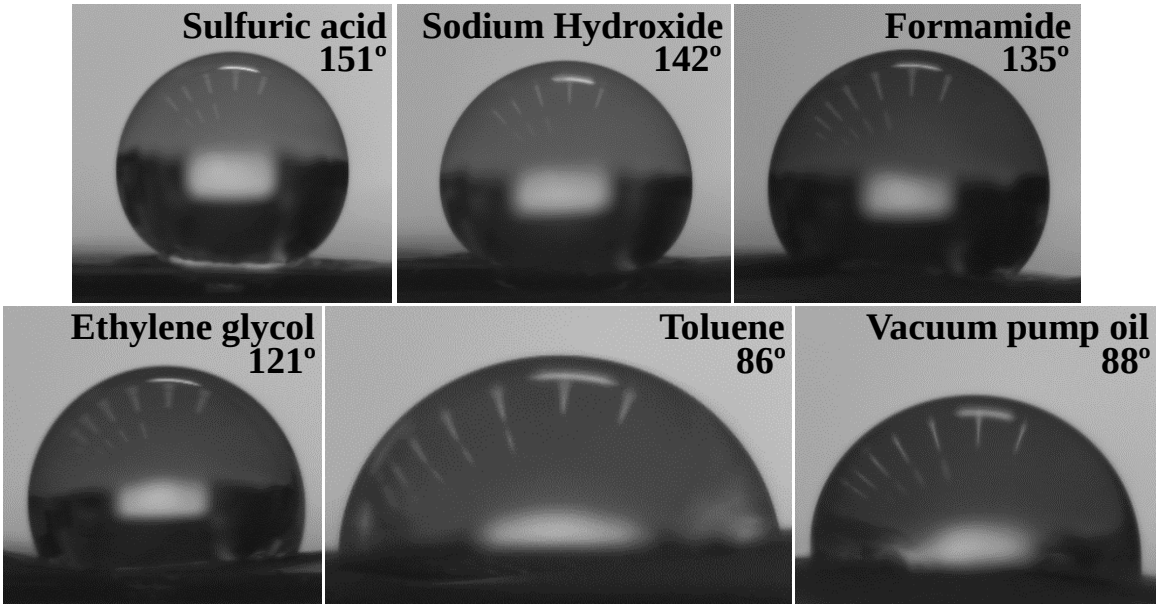

Fig.S-6 Various liquid droplets on the amphiphobic surface of FOTS treated 0.1wt% nanocellulose-modified PTFE filter paper.