Electronic Supplementary Material (ESI) for Lab on a Chip
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ELECTRONIC SUPPLEMENTARY INFORMATION (ESI)

Flexible Microfluidic Cloth-based Analytical Devices Using Low-Cost Wax Patterning Technique

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I. Scanning Electron Microscopy (SEM) of Cotton Fiber

Scanning Electron Microscopy (SEM) imaging was conducted on the untreated and scoured cotton fabrics samples using Low-Vacuum SEM JEOL JSM-6390. Figure S1, S2, and S3 show the images of untreated, NaOH-scoured, and Na_2CO_3-scoured cotton fiber, respectively.

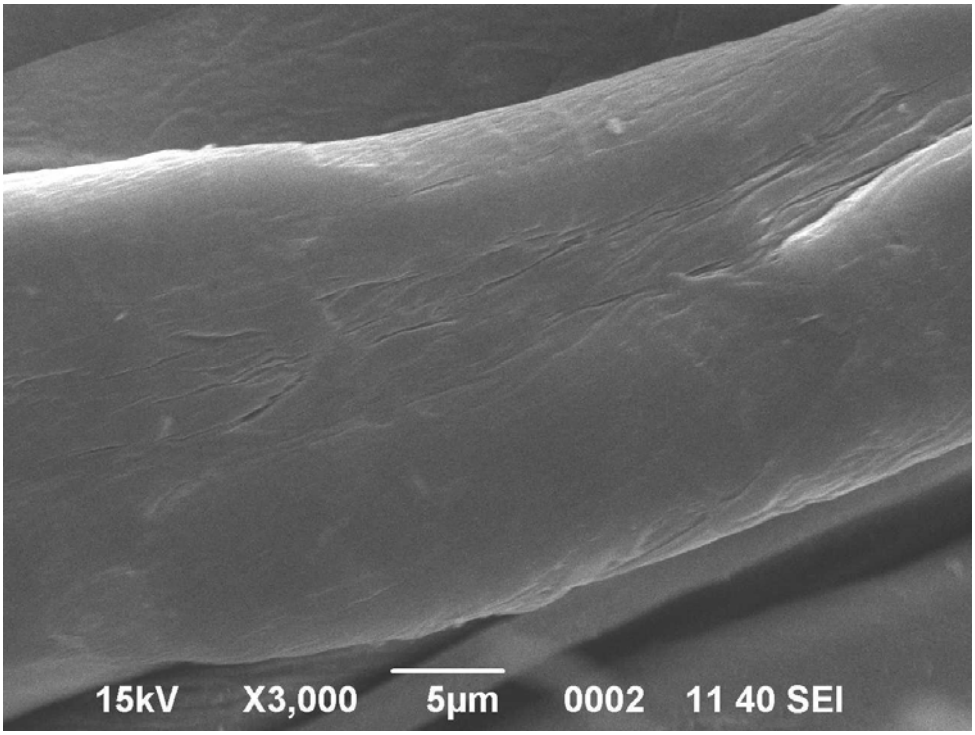

Figure S1. Secondary electron image (SEI) SEM image of cotton fiber before scouring, showing an outer layer of natural wax on its wall

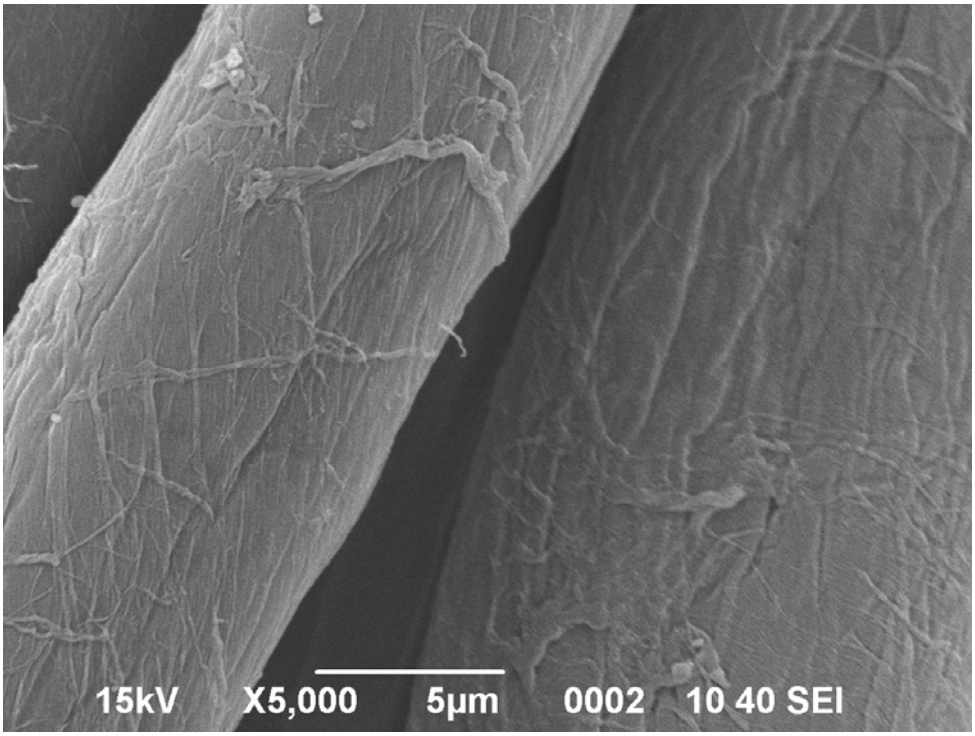

Figure S2. Secondary electron image (SEI) SEM image of cotton fiber after NaOH scouring/mercerization, showing the underlying spiral winding cellulose with some remain of the non-cellulosic materials

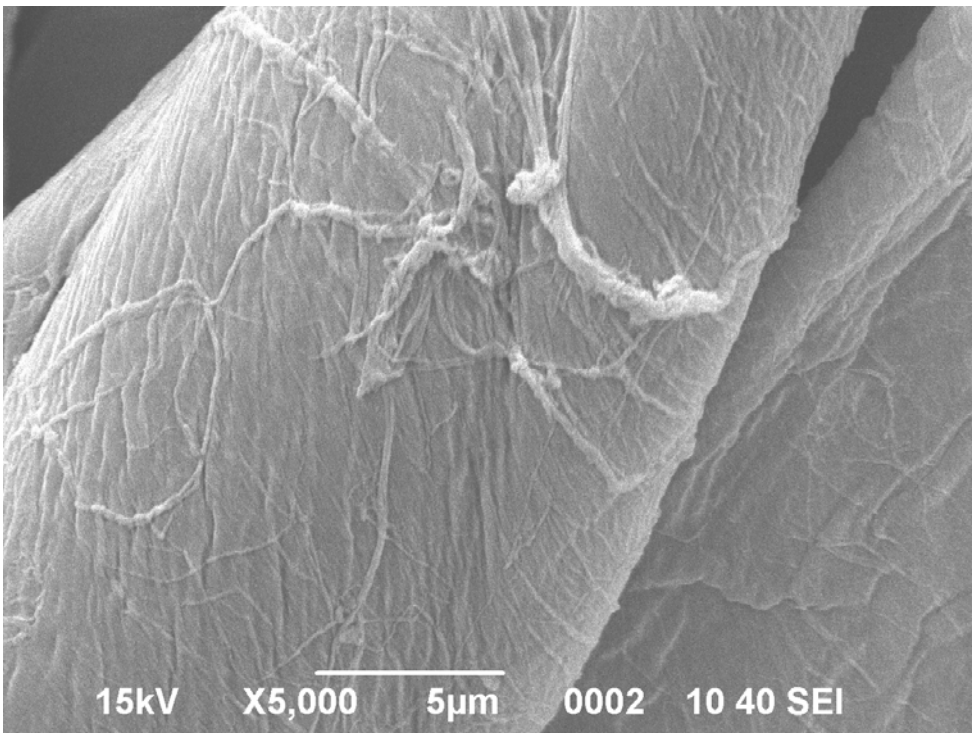

Figure S3. Secondary electron image (SEI) SEM image of cotton fiber after Na_2CO_3 scouring/bleaching, showing the underlying spiral winding cellulose with some remain of the non-cellulosic materials, similar as the result of NaOH scouring

II. Field-Emission Scanning Electron Microscopy (FESEM) of Cotton Fabrics

FESEM imaging was conducted on cotton fabrics on which silver (Ag) nanoparticles ink were dropped, as described in the Materials and Methods section of the main paper. FESEM was carried out using Cold FESEM Hitachi SU-8000 in its low-angle backscattered electron (LA-BE) imaging mode. This mode enables high-contrast observation of the nanoparticle on the cotton fabrics. Results are shown in figure S4, S5, and S6 for the untreated, NaOH-scoured and Na_2CO_3-scoured cotton fabrics, respectively.

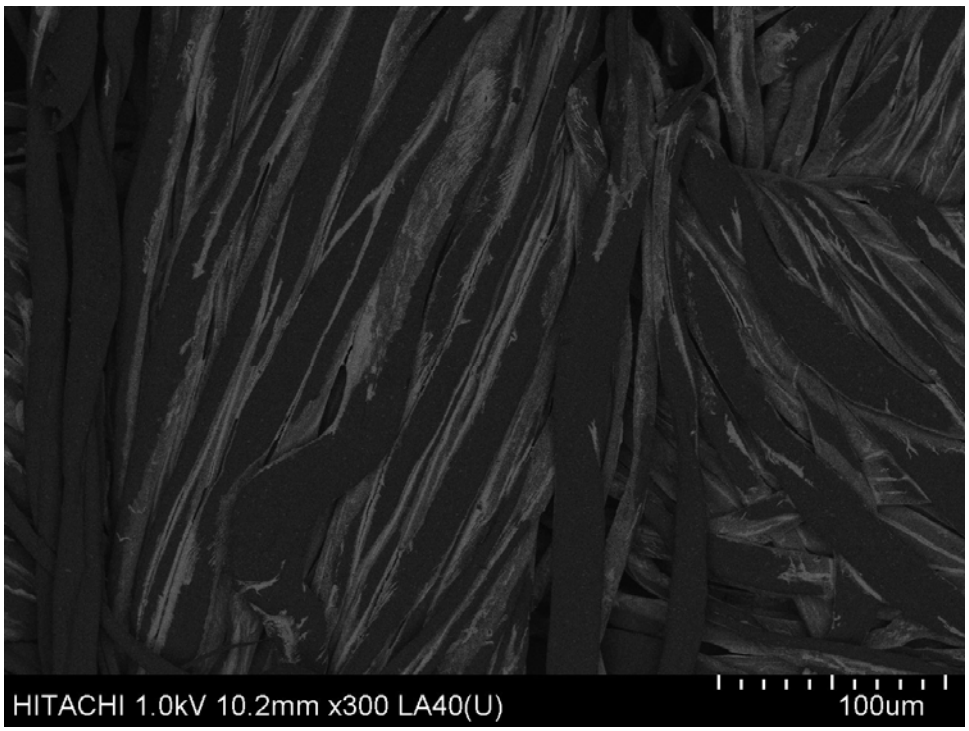

Figure S4. Low-angle backscattered electron image (LA-BE) FESEM image of silver (Ag) nanoparticle ink flown into untreated cotton fabrics. Brighter parts indicate the Silver element which has heavier atomic weight.

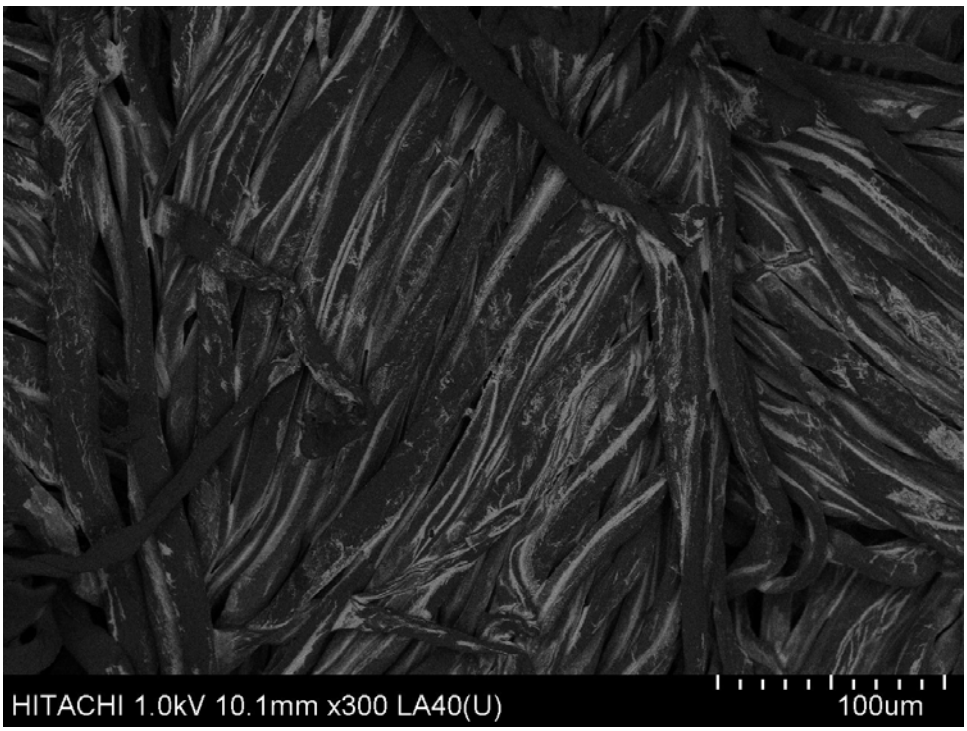

Figure S5. Low-angle backscattered electron image (LA-BE) FESEM image of silver (Ag) nanoparticle ink flown into .NaOH-scoured cotton fabrics. Brighter parts indicate the Silver element which has heavier atomic weight.

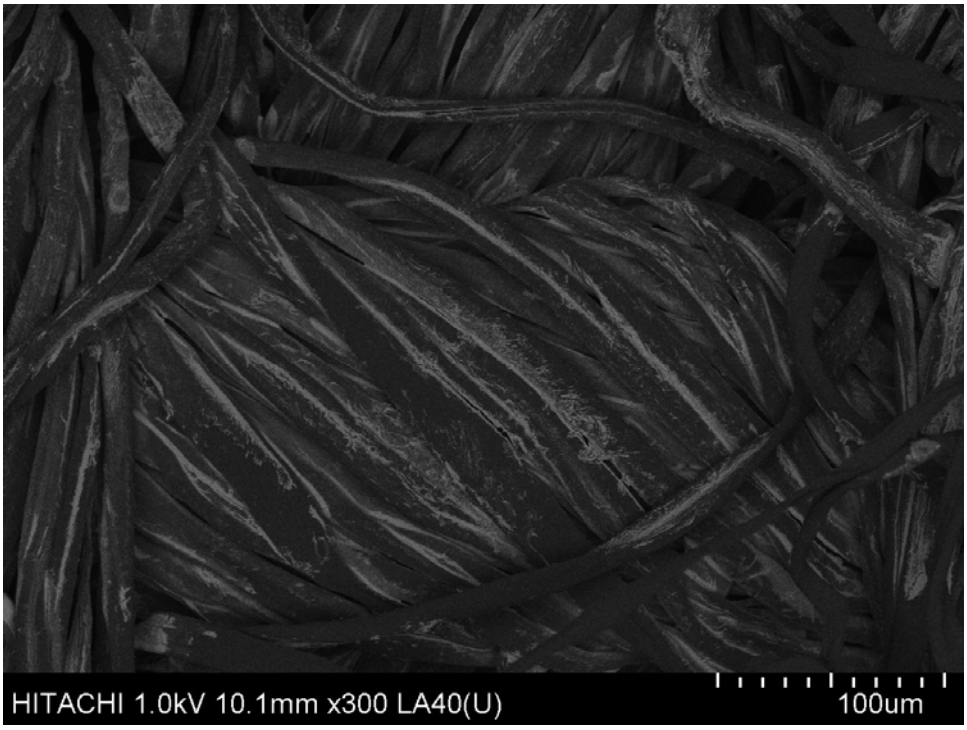

Figure S6. Low-angle backscattered electron image (LA-BE) FESEM image of silver (Ag) nanoparticle ink flown into Na_2CO_3-scoured cotton fabrics. Brighter parts indicate the Silver element which has heavier atomic weight.

III. Energy-Dispersive Electron Spectroscopy (EDS) of Cotton Fabrics

EDS was carried out using Oxford INCA EDX attached to FESEM JEOL JSM-7600F. Another series of EDS was also performed using similar machine attached to Hitachi Tabletop SEM TM3000.

Figure S7 shows the SEM images of the investigated non-wax area of untreated (A), NaOH-scoured (C) and Na_2CO_3-scoured (E) cotton fabrics, with their EDS spectra in (B), (D), and (F), respectively. The Atomic percentage composition of Carbon and Oxygen atoms from each sample is listed in table S1.

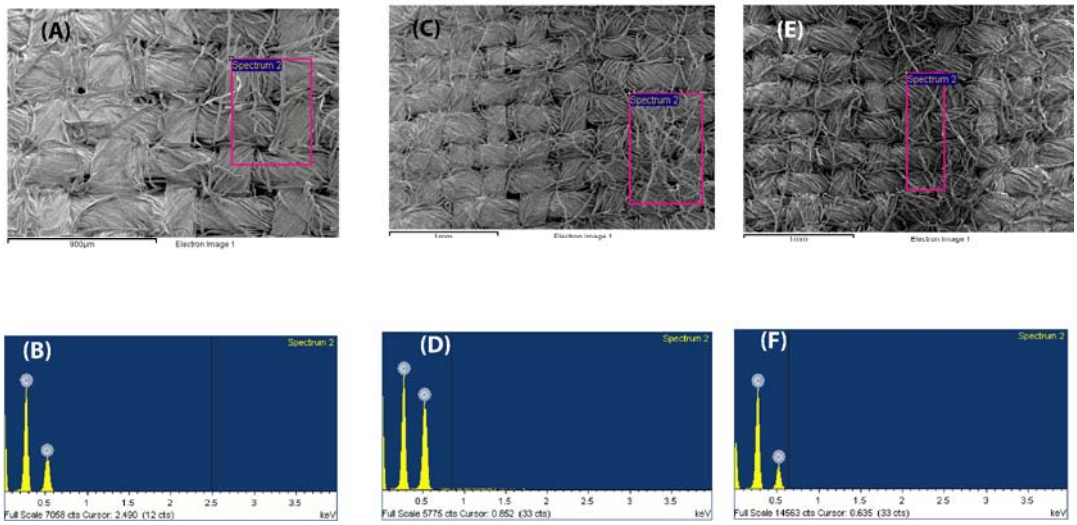

Figure S7. SEM and the corresponding EDS spectra of the unwaxed regions in untreated (A)-(B), NaOH-scoured (C)-(D), and Na_2CO_3-scoured (E)-(F) cotton fabrics, respectively.

Table S1. Carbon and Oxygen atomic composition in percentage, of the non-wax area from untreated and scoured cotton fabrics, based on EDS spectra shown in fig. S7

Treatment	Atomic % C	Atomic % O	O/C ratio
Without treatment	59.33	40.67	0.69
NaOH-scoured	54.67	45.33	0.83
Na_2CO_3-scoured	64.84	35.16	0.54

The result of EDS performed in Tabletop Hitachi SEM TM3000 is listed in table S2

Table S2. Carbon and Oxygen atomic composition in percentage, of the non-wax area from untreated and scoured cotton fabrics, based on EDS spectra on a different machine, TM 3000.

Treatment	Atomic % C	Atomic % O	O/C ratio
Without treatment	54.336	45.664	0.840
NaOH-scoured	54.277	45.723	0.842
Na_2CO_3-scoured	57.025	42.975	0.754

Figure S8 shows the SEM images of the investigated waxed area of untreated (A), NaOH-scoured (C) and Na_2CO_3-scoured (E) cotton fabrics, with their EDS spectra in (B), (D), and (F), respectively. The Atomic percentage composition of Carbon and Oxygen atoms from each sample is listed in table S3.

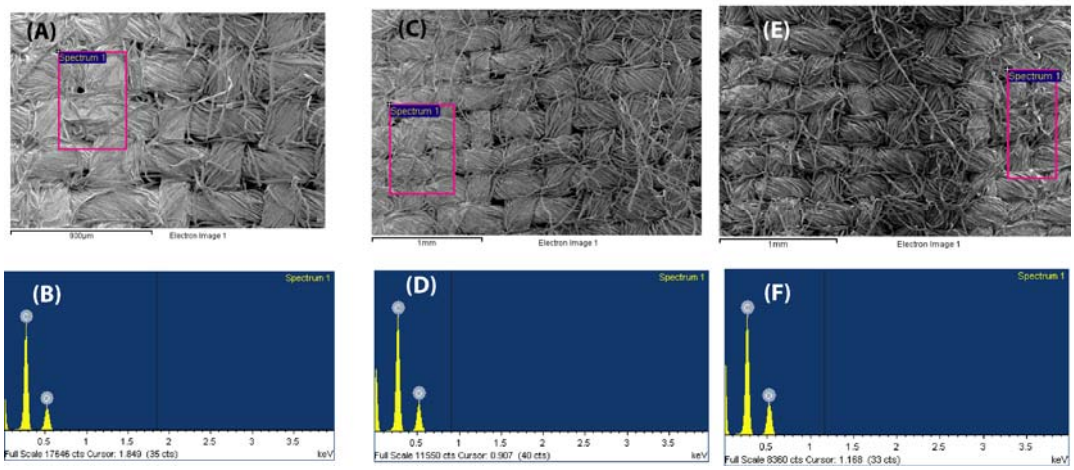

Figure S8. SEM and the corresponding EDS spectra of the waxed regions in untreated (A)-(B), NaOH-scoured (C)-(D), and Na_2CO_3-scoured (E)-(F) cotton fabrics, respectively.

Table S3. Carbon and Oxygen atomic composition in percentage, of the wax area in the untreated and scoured cotton fabrics, based on EDS spectra shown in fig. S8.

Treatment	Atomic % C	Atomic % O	O/C ratio
Without treatment	75.69	24.31	0.32
NaOH-scoured	73.28	26.72	0.36
Na_2CO_3-scoured	72.77	27.23	0.37

IV. X-Ray Photoelectron Spectroscopy (XPS) of Cotton Fabrics

EDS results only show qualitative data on the elemental composition on the surface of the untreated and scoured fabrics. To get a more quantitative data on the chemical binding state of the elements, i.e. Carbon (C) atom and Oxygen (O) atom, XPS characterisation was conducted on the untreated, scoured and waxed cotton fabrics respectively. XPS was carried out using Kratos AXIS Ultra DLD Photoelectron Spectrometer.

Figure S9 shows high resolution XPS spectra of the untreated and scoured cotton cloth. Figure S10 shows the C 1s peaks of XPS spectrum from waxed cotton cloth. Table S4 shows the relative concentration of the different peaks from the different cotton cloth specimens: C1 peak (285 eV) indicating C-C bond, C2 peak (286.7 eV) indicating **C**-O bond, C3 peak (288.2 eV) indicating O-**C**-O bond, and C4 peak (289.3 eV) indicating O-**C**=O bond. Table S5 shows the elemental relative concentration from each respective sample, based on the XPS characterization.

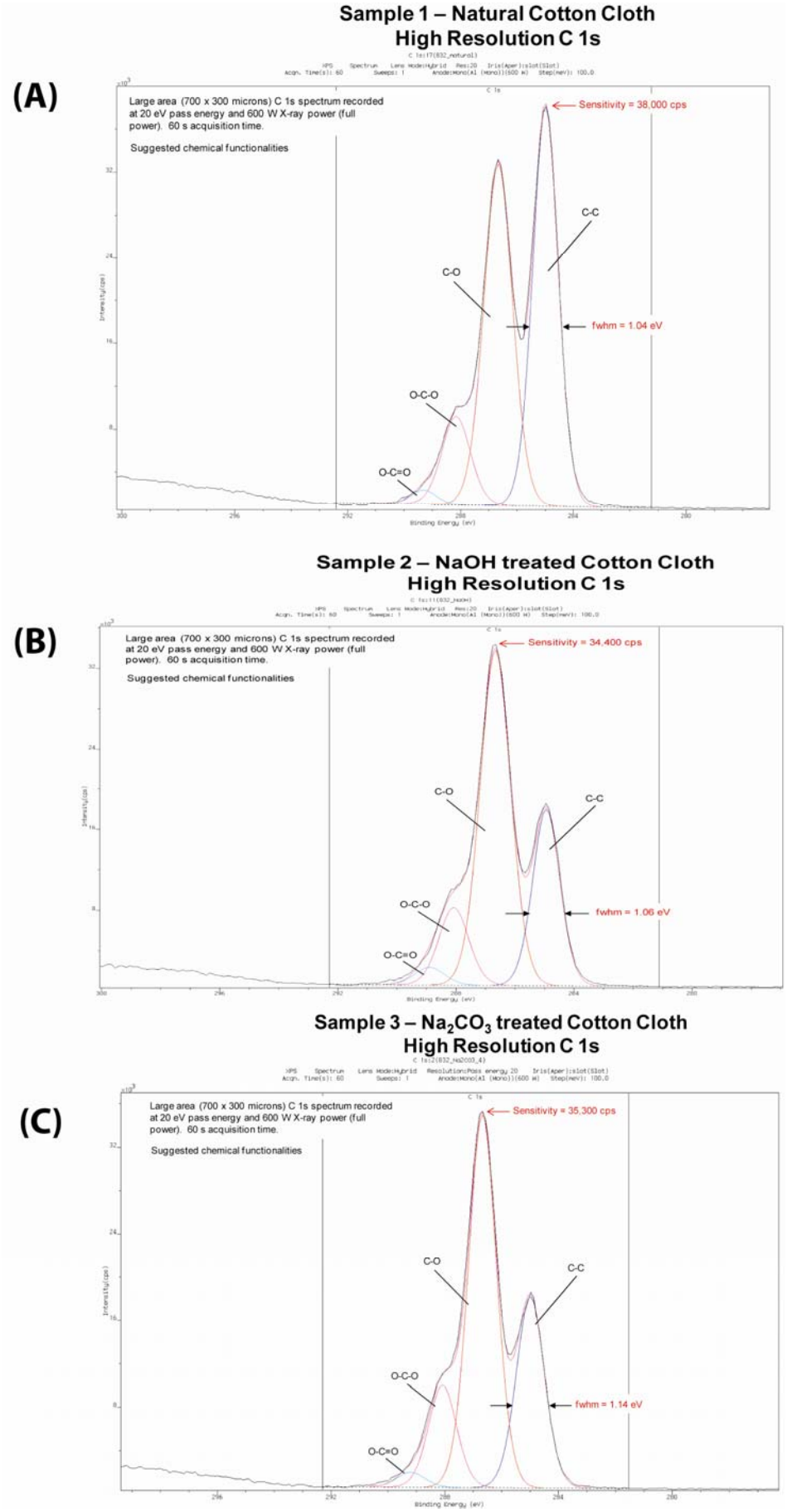

Figure S9. High resolution C 1s peaks from the XPS spectra of untreated (A), NaOH-scoured (B), and Na_2CO_3-scoured (C) cotton cloth, respectively.

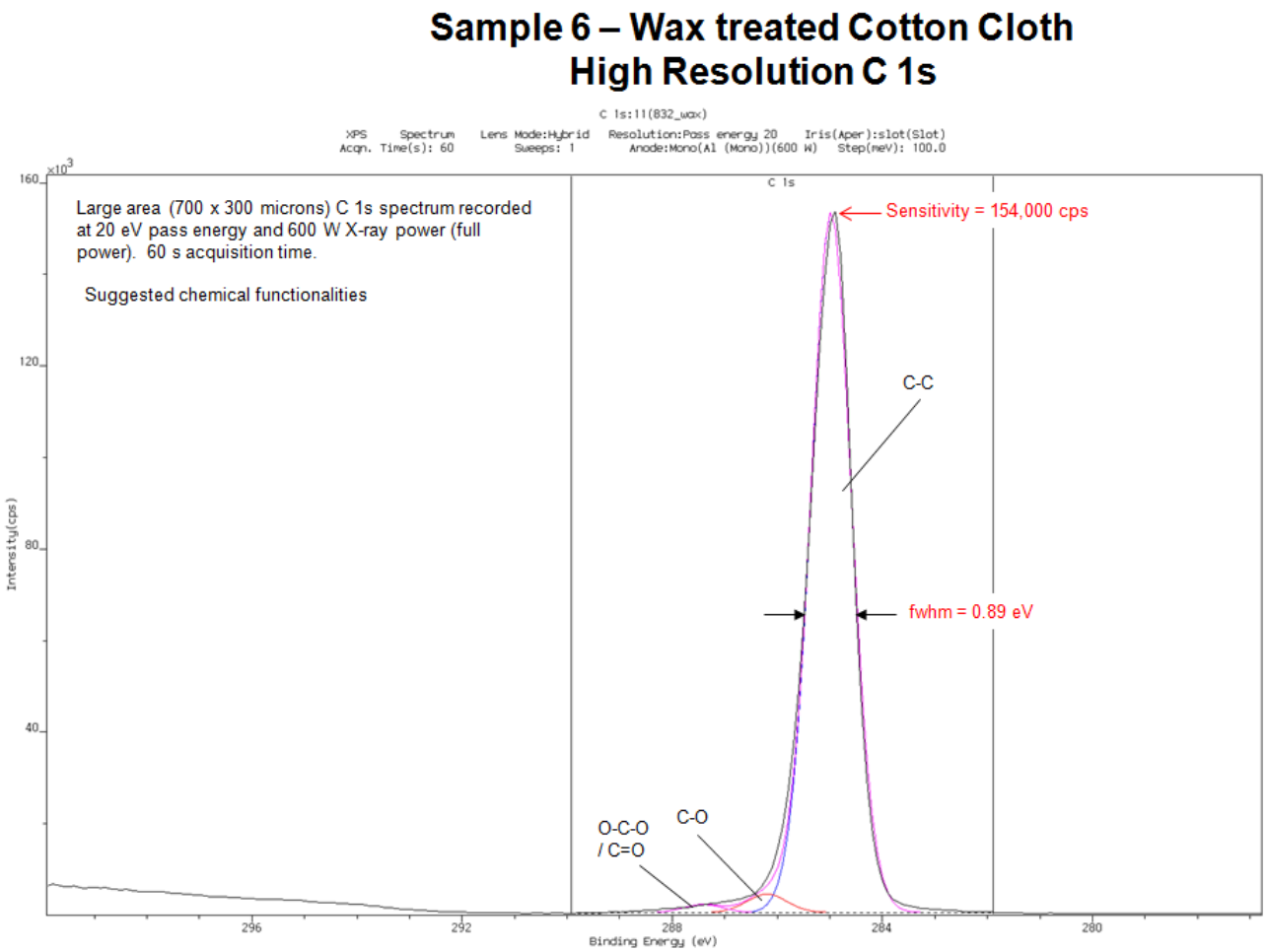

Figure S10. C 1s peaks from the XPS spectra of Waxed Cotton Cloth.

Table S4. Relative concentration of the different C atom binding state from the untreated, scoured and waxed cotton cloth samples, based from XPS spectra shown in fig. S9 and fig. S10.

Relative concentration /%	C-C or C-H aliphatic	**C**-O (alcohols C-OH or C-O-OH and ethers)	O-**C**-O (acetal) or C=O double ether, carbonyl	O-**C**=O (carboxyl)	C-C decrease /%
Untreated	44.47	42.79	11.16	1.57	0
NaOH treated	26.85	57.13	13.02	3	39.62222
Na_2CO_3 treated	28.12	54.68	15.02	2.18	36.76636
Wax treated	96.25	2.58	1.16	-	-116.438
Binding energy / eV	285	286.7	288.2	289.3	

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Table S5. Elemental concentration from the untreated, scoured and waxed cotton cloth samples, based from XPS characterization.

Elemental concentration / at %	C	O	Ca	N	Si	S	O/C ratio
Untreated	69.39	29.2	0.49	0.56	0.23	0.13	0.42
NaOH treated	63.64	35.89	0.11	0.24	0.12		0.56
Na_2CO_3 treated	64.33	35.09	0.14	0.25	0.19		0.55
Wax treated	99.48	0.46			0.06		0.00

V. Optical Microscopy of Wicking in Single Cotton Fiber

To prove that the increased wicking in NaOH- and Na_2CO_3-scoured cotton is due to the additional wicking mechanism along a single fiber, we conducted optical microscopy observation of wicking along a single cotton fiber of untreated, NaOH- and Na_2CO_3-scoured cotton. The fibers were extracted from each respective cotton fabrics samples. Figure S11 shows the optical light microscopy images of single cotton fibers without treatment (A) and after scouring with NaOH (B) and Na_2CO_3 (C), after the application of 100 nl of red ink solution on top of the fibers' ends.

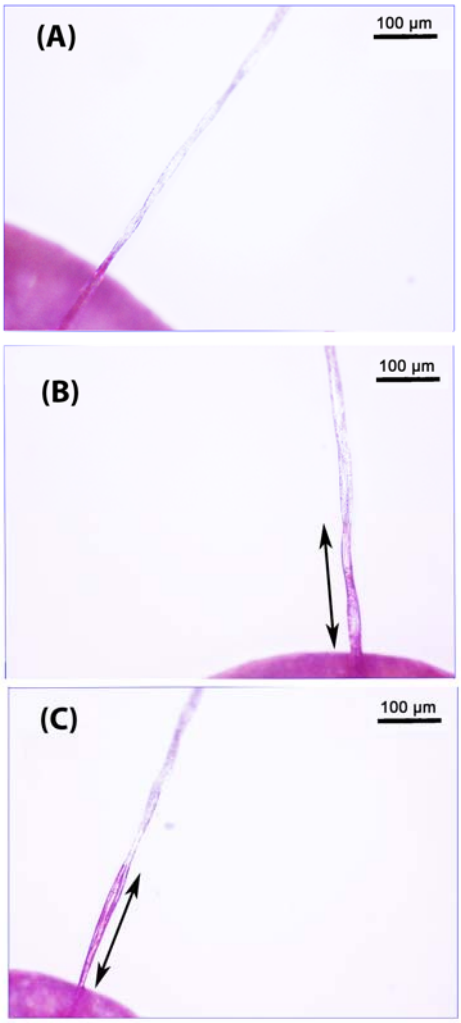

Figure S11 Wicking of red ink in single fiber of untreated (A), NaOH-scoured (B), and Na_2CO_3-scoured (C) cotton. The red curve at the bottom of each picture is the 100 nl ink droplet reservoir