Supporting Information

Title: Fabrication of innovative multifunctional dye using MXene nanosheets

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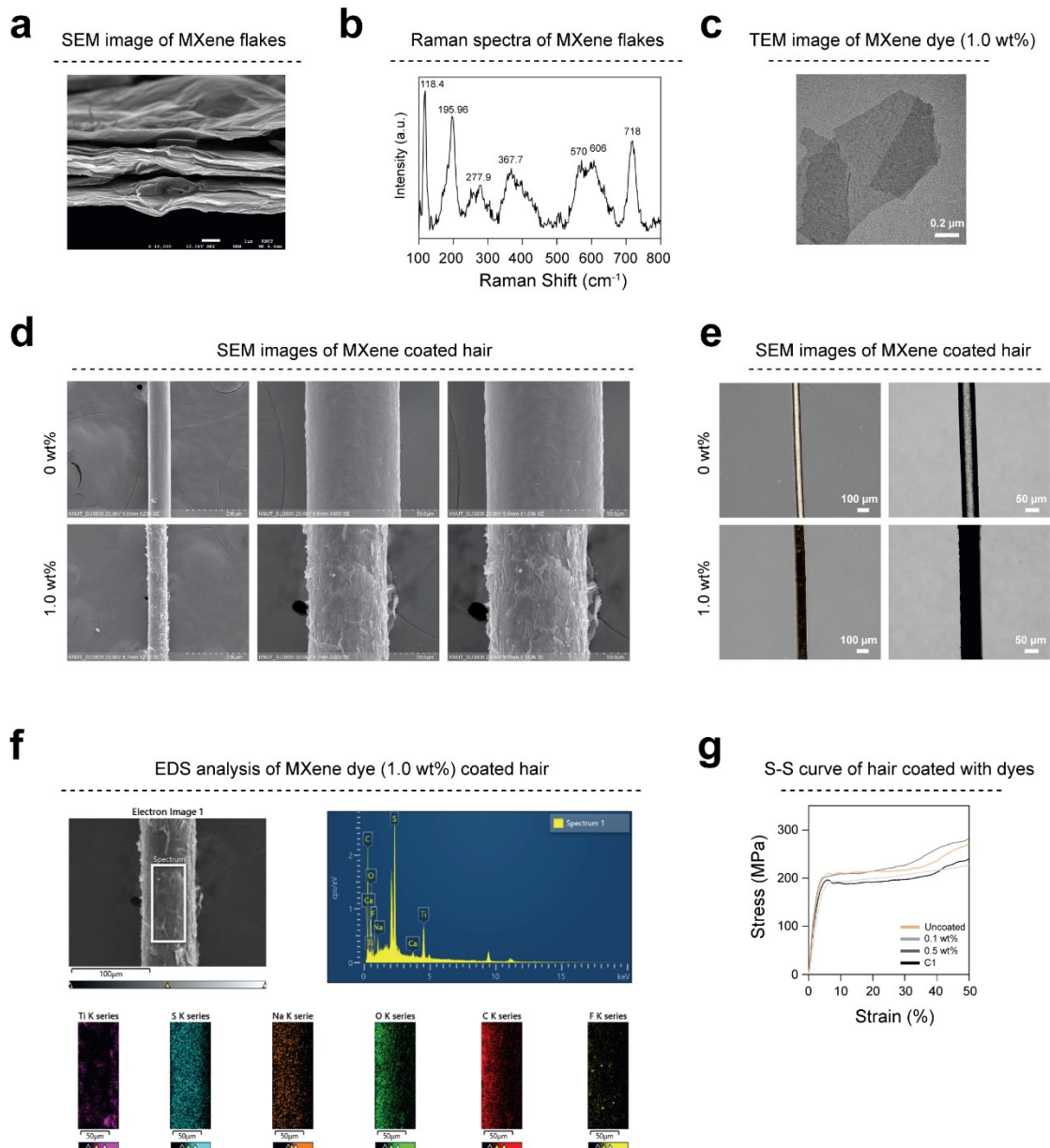
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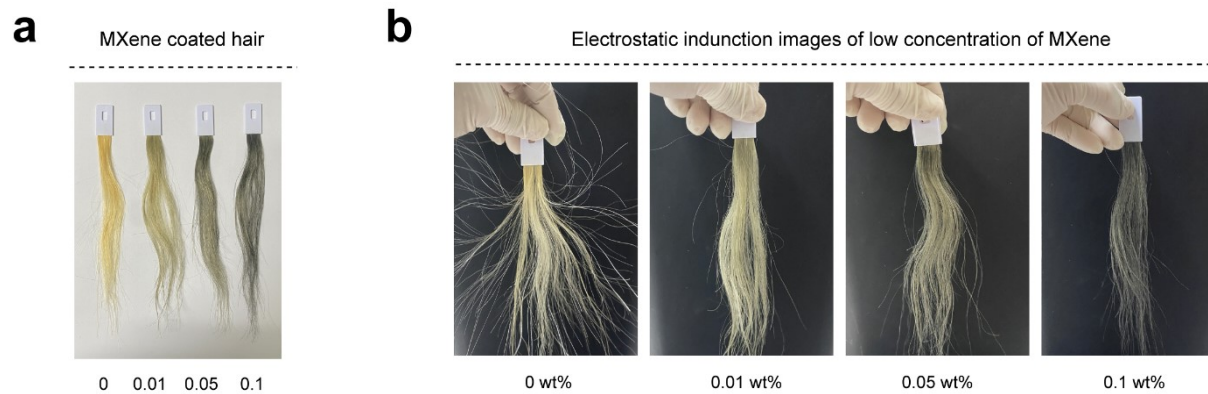
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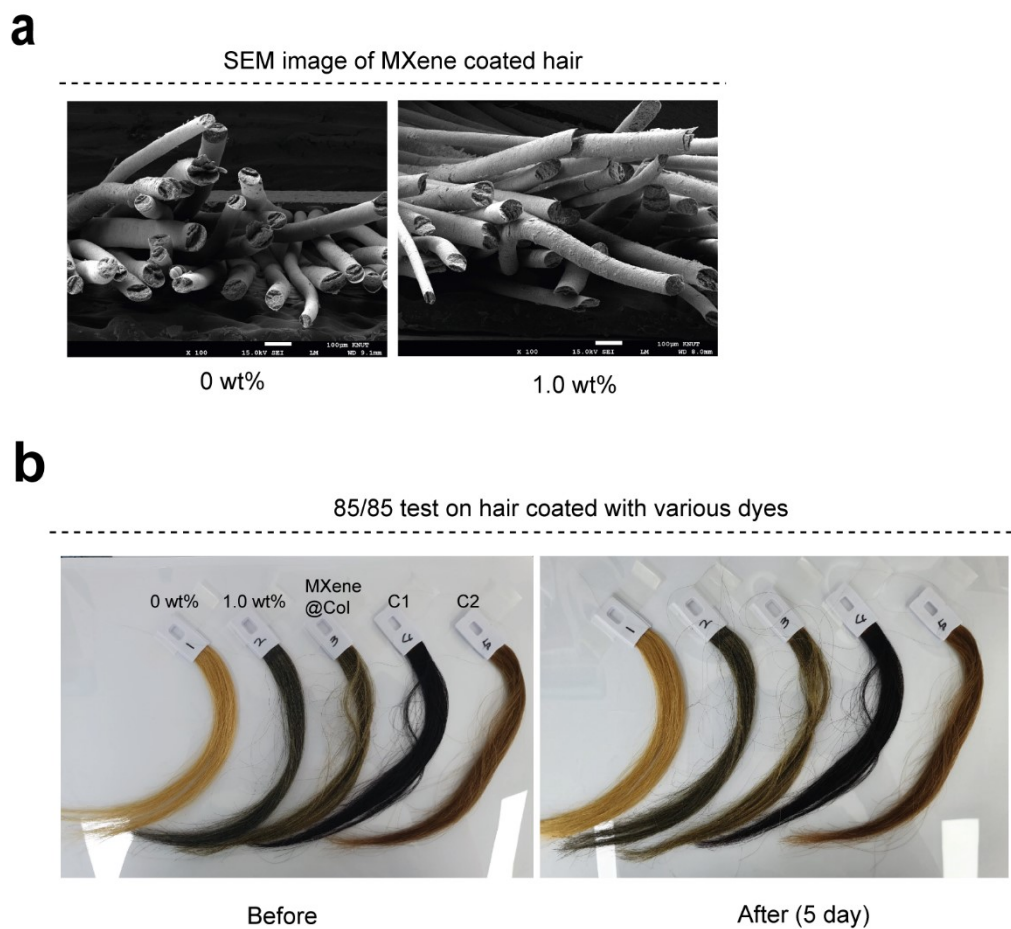
a SEM image of MXene flakes

b Raman spectra of MXene flakes

c TEM image of MXene dye (1.0 wt%)

d SEM images of MXene coated hair

e SEM images of MXene coated hair

f EDS analysis of MXene dye (1.0 wt%) coated hair

g S-S curve of hair coated with dyes

Fig. S1 Characterization of MXene flakes and MXene dye.

(a) SEM image of MXene flakes. (b) Raman spectra of Ti_3C_2 MXene flakes. (c) TEM image of MXene dye (1.0 wt%). (d, e) SEM and microscope images of uncoated hair (0 wt%) (top) and MXene dye coated hair (1.0 wt%) (bottom). (f) EDS mapping images of MXene dye coated hair. (g) Stress-strain curves of MXene dyes at various concentrations and commercial hair dyes.

a MXene coated hair

0   0.01   0.05   0.1

b Electrostatic indunction images of low concentration of MXene

0 wt%   0.01 wt%   0.05 wt%   0.1 wt%

Fig. S2 Gross image and electrostatic properties of hair coated with various concentrations of MXene dye.

(a) Gross images of hair coated with different concentrations (0 wt%, 0.01 wt%, 0.05 wt%, 0.1 wt%) of MXene dye. (b) Antistatic properties of hair coated with MXene dye at various concentrations.

a

SEM image of MXene coated hair

0 wt%   1.0 wt%

b

85/85 test on hair coated with various dyes

0 wt%   1.0 wt%   MXene@Col   C1   C2

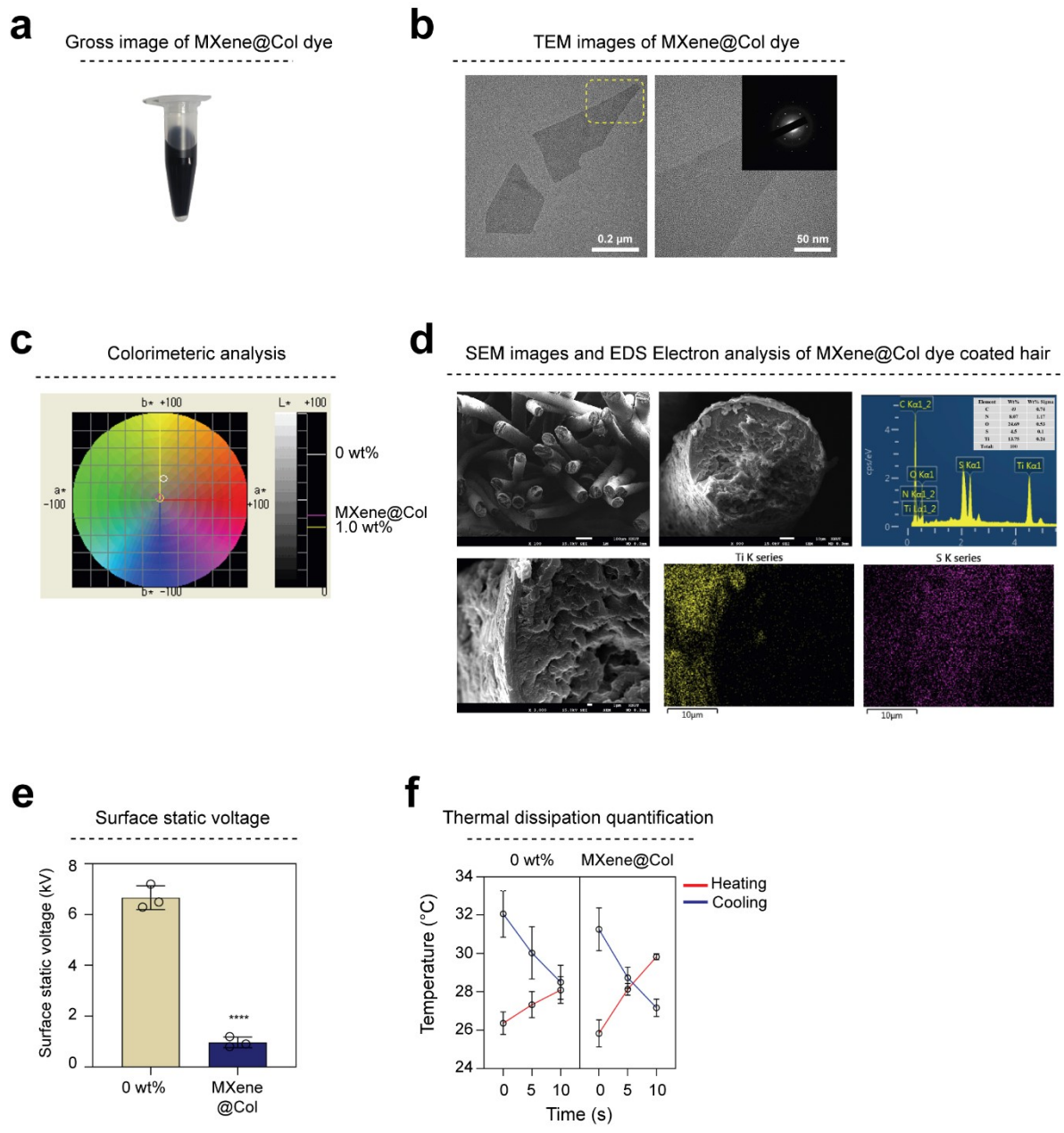Before   After (5 day)

Fig. S3 Durability properties of hair coated with various dyes.

(a) Cross-sectional SEM images of uncoated hair (0 wt%) (top) and hair coated with MXene dye (1.0 wt%) (bottom). (b) 85/85 test (Temperature 85 ℃, relative humidity 85 %) of hair coated with various dyes Before and After (Day 5) images.
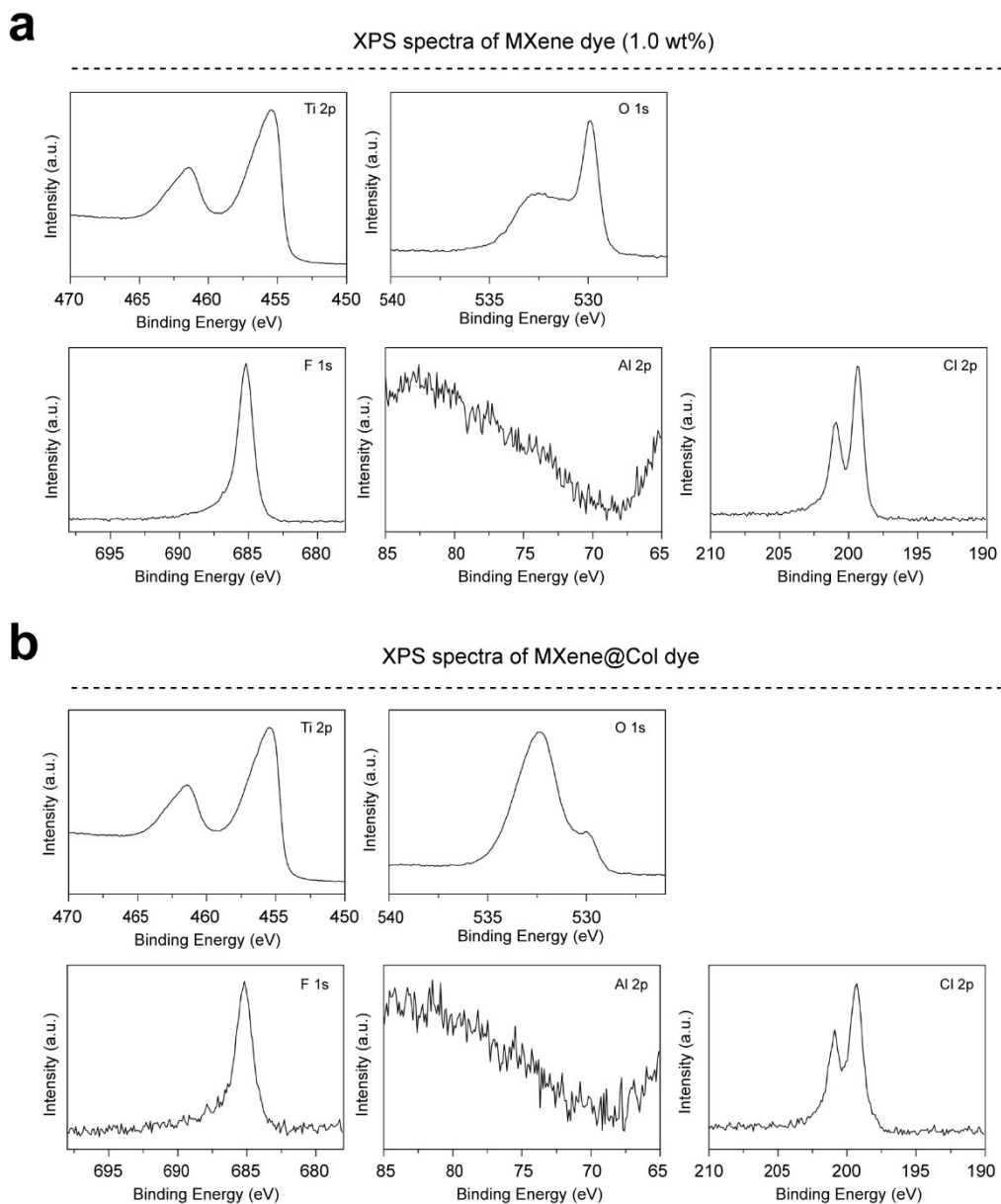
Fig. S4. XPS spectrum of MXene dye and MXene@Col dye

(a, b) XPS corresponding spectra of Ti 2p, O 1s, F 1s, Al 2p, Cl 2p for MXene dye and MXene@Col dye.

a Gross image of MXene@Col dye

b TEM images of MXene@Col dye

0.2 μm

50 nm

c Colorimeteric analysis

b+ +100

L+ +100

a* −100

a* +100

0 wt%

MXene@Col 1.0 wt%

b+ −100

0

d SEM images and EDS Electron analysis of MXene@Col dye coated hair

C Kα1_2

O Kα1

Si Kα1

Ti Kα1

N Kα1_2

Ti Lα1_2

Ti K series

S K series

10μm

10μm

e Surface static voltage

Surface static voltage (kV)

8

6

4

2

0

0 wt%

MXene @Col

****

f Thermal dissipation quantification

0 wt%   MXene@Col

Temperature (°C)

34

32

30

28

26

24

0 5 10   0 5 10

Time (s)

Heating

Cooling

Fig. S5. Characterization of MXene dye surface modified with collagen

(a) Gross image of MXene@Col dye. (b) TEM amd SAED images of MXene@Col dye. (c) Colorimeter analysis images of uncoated hair (0 wt%), hair coated with MXene dye (1.0 wt%), and hair coated with MXene@Col dye. (d) SEM and EDS mapping analysis image of hair coated with MXene@Col dye. (e) Surface static voltage of MXene@Col coated hair. (f) Termal dissipation quantification of MXene@Col coated hair. ****$p<0.0001$ The symbol * indicates comparisons with 0 wt%.

Table S1. Electromagnetic interface (EMI) shielding efficiency data of various hiar dye

		0 wt%	1.0 wt%	MXene@Col	C1	C2
EMI SE (dB)	1st	1.511	6.193	1.81	1.293	1.843
	2nd	1.512	6.132	1.858	1.339	1.743
	3rd	1.518	6.12	1.776	1.31	1.728
	Ave.	1.51	6.14	1.81	1.314	1.78

Table S2. Hair samples coated with or without MXene dye (1.0 wt%) and MXene@Col dye and zeta potential data table for each dye

		0 wt%	1.0 wt%	MXene@Col	MXene solution	MXene@Col solution
Zeta potential (mV)	1st	-16.44	-21.74	-9.29	-44.54	27.09
	2nd	-17.16	-22.19	-6.33	-41.10	28.83
	Ave.	-16.8	-21.97	-7.81	-42.82	27.96

Table S3. Colorimeter data table of uncoated hair (0 wt%), hair coated with MXene dye (1.0 wt%), and hair coated with MXene@Col dye.

	0 wt%	1.0 wt%	MXene@Col
L* (100 White / 0 Black)	76.45	34.61	41.44
a* (+ Red / - Green)	3.02	-0.37	-0.95
b* (+ Yellow / - Blue)	25.36	2.68	3.07