**Electronic Supplementary Information**

# Preparation of cellulose colloidal particles in aqueous solution with good photochromic and photoluminescent performances by grafting a spiropyran derivative onto filter paper cellulose

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8. **Synthetic process of the SP-COOH.**

The synthesis of the SP-COOH referred to the literature1,2.



**Fig. S1** Synthetic routine of the SP-COOH.

**1.1** **1-(2-carboxyethyl)-2,3,3-trimetyl-3H-indolium bromide**

A mixture of 2,3,3-trimethyl-3H-indole (3.18 g, 20 mmol) and 3-bromopropionic acid (3.06 g, 20 mmol) in 2-butanone (25 mL) was refluxed under nitrogen at 85 °C for 4 h. Then 2-butanone was removed under reduced pressure distillation to obtain the residue. The residue was recrystallized with acetone under stirring. Then, the solid was washed three times with acetone (15 mL) to remove unreacted starting material and a pale pink solid (5.05 g, 81%) was finally obtained.

**1.2 3-(3′,3′-Dimethyl-6-nitrospiro[chromene-2,2′-indolin]-1′-yl)****propanoic acid**

A solution of 1-(2-carboxyethyl)-2,3,3-trimethyl-3H-indolium bromide (5.05 g, 16 mmol), 2-hydroxy-5-nitrobenzaldehyde (2.71 g, 16 mmol) and piperidine (1.38 g, 16 mmol) in 2-butanone (25 mL) was refluxed under nitrogen at 85 °C for 4 h. The reaction solution was cooled to room temperature and standing overnight. The precipitate was obtained by filtration and washed with cool ethanol. After drying in vacuum, crude powder (3.25 g, 53%) was obtained. The crude product was further purified by a silica gel column with acetone/chloroform (1/1, v/v). Finally, the yellow-green powder (2.44 g, 40%) of the product was procured.

1. **The FTIR spectrum of the SP-COOH.**



**Fig. S2** The FTIR spectrum of the SP-COOH.

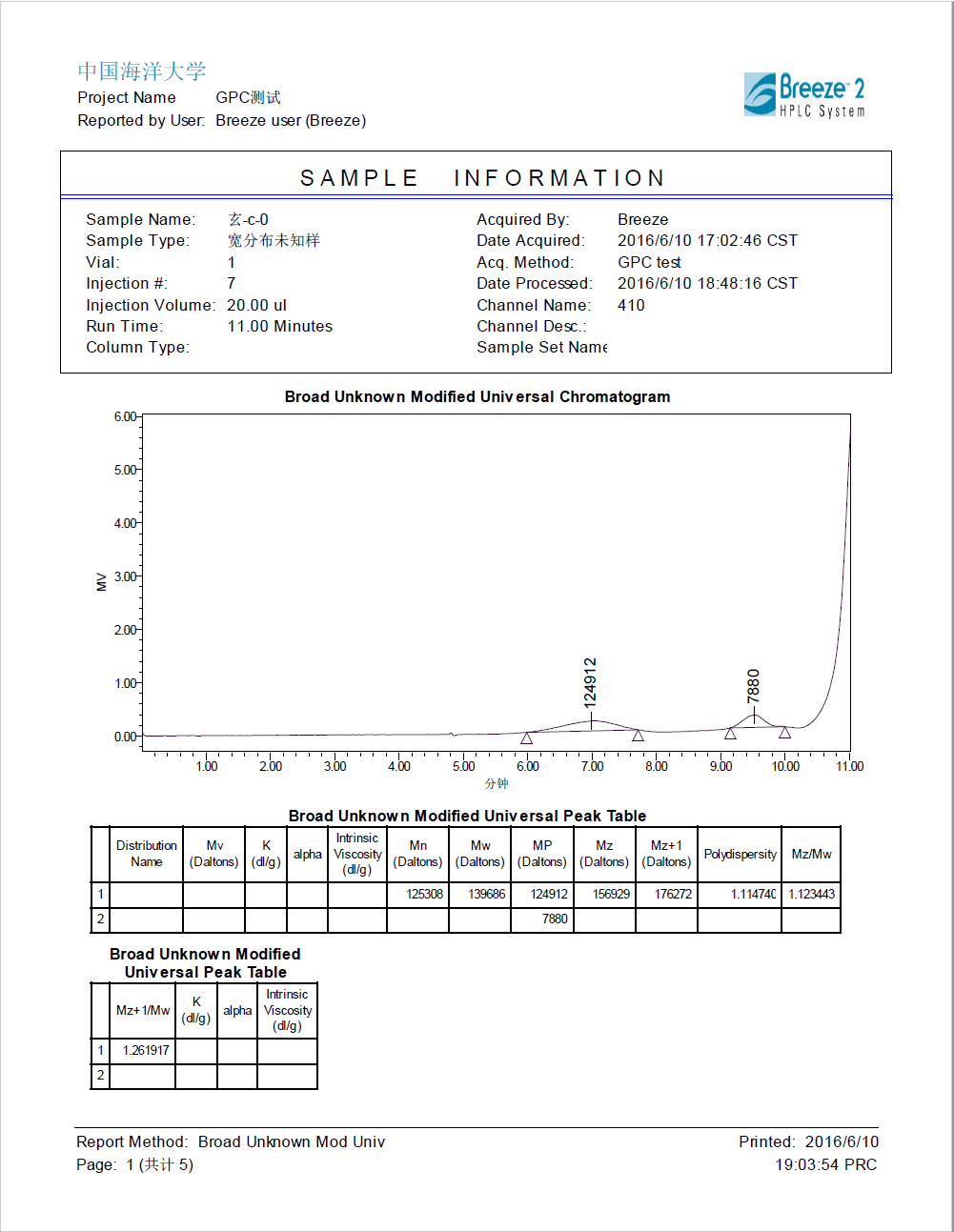
1. **The 1H NMR spectrum of the SP-COOH.**



**Fig. S3** The 1H NMR spectrum of the SP-COOH.

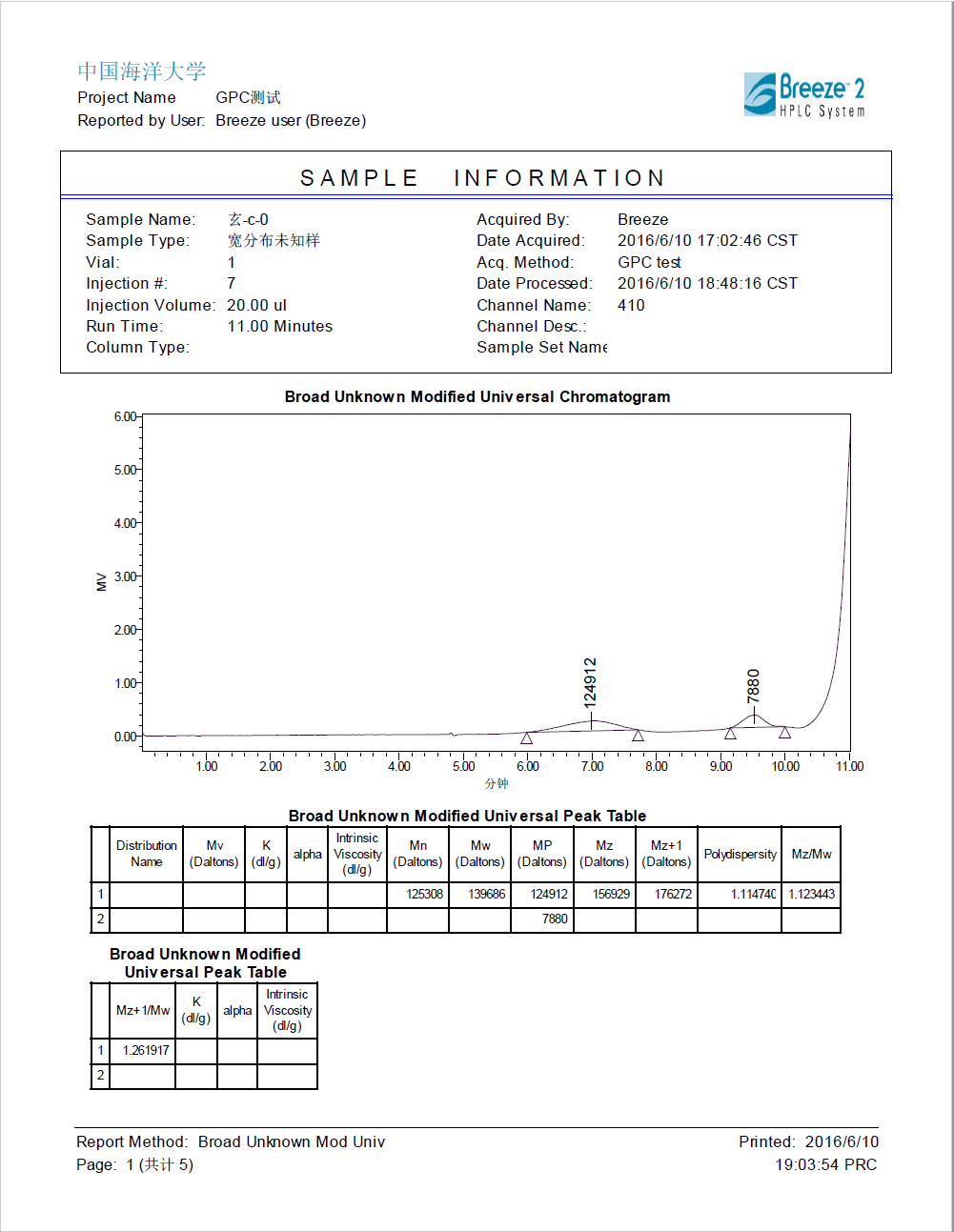
1H NMR (400 MHz, CDCl3, ppm) δ: aromatic protons, 8.04 – 7.94 (m, 2H), 7.21 (t, J = 7.1 Hz, 1H), 7.08 (d, J = 6.8 Hz, 1H), 6.91 (m, 2H), 6.73 (d, J = 9.2 Hz, 1H); 6.59 (d, J = 7.9 Hz, 1H), 5.83 (d, J = 10.3 Hz, 1H); 3.68 – 3.59 (m, 1H), 3.58 – 3.49 (m, 1H), 2.74 – 2.53 (m, 2H); 1.26 (s, 3H), 1.14 (s, 3H).

1. **GPC data of the SP-Cellulose**



**Fig. S4** The GPC curve of the SP-Cellulose.

**Table. S1** Data obtained from Fig. S3



1. **A rough estimation of the** **grafting rate and the degree of substitution of the SP-Cellulose via esterification.**



**Fig. S5** Absorbance–concentration linear standard calibration curves of the SP-COOH (a) and SP-Cellulose (b) in ethanol.

The absorbance–concentration linear standard calibration curves of the SP-COOH (1) and the SP-Cellulose (2):

(1)

(2)

where *x1* and *x2* are the concentrations of the SP-COOH and the SP-Cellulose in ethanol, *y1* and *y2* are the absorbance of the SP-COOH and the SP-Cellulose at 336 nm in ethanol, *R2* is the square of linearly dependent coefficient.

Since the UV-Vis absorption of the SP-Cellulose comes from spiropyran, the absorption values of the SP-COOH and the SP-Cellulose at 336 nm were equal when the content of spiropyran in the SP-Cellulose is equal to the SP-COOH. Then the grafting rate (g/g) of the SP-Cellulose was calculated as follow:

All the concentrations of the SP-COOH and the SP-Cellulose used for testing in this study are determined by the derived grafting rate.

As suggested by some researchers, there are three hydroxyl groups that can be substituted in each glucose unit in cellulose, and the degree of substitution (*DS*) is no more than 3.3 The *DS* in this research was calculated by the following formula:

where *ns* and *nt* are the amount of substance of the substituted hydroxyl and total original hydroxyl in the SP-Cellulose. Set the mass of the SP-Cellulose is *m*, then *ns* and *nt*can be calculated by the following formula respectively:

So,

1. **Relative fluorescence quantum yield of SP-COOH and SP-Cellulose samples in different solvents**



**Fig. S6** The relative fluorescence quantum yield of all SP-COOH and SP-Cellulose samples in different solvents in Fig. 5c and 5d

The figure indicates that the fluorescence quantum yield of the SP-COOH and SP-Cellulose is strongly affected by the solvent.

The fluorescence quantum yield is calculated by the following formula:

where, φu refers to the fluorescence quantum yield of an unknown sample, φs refers to the fluorescence quantum yield of a reference sample, Iu, Is and Au, As are their corresponding fluorescence integral intensities and absorbances, respectively. In this section, we set a SP-COOH solvent sample with 100% ethanol as the reference sample and its fluorescence quantum yield as m. The data used for above calculation is shown in the table below. The original data is obtained from Figure 5.

**Table. S2** Data obtained from Fig. 5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| sample | solvent | Iu | Au | φu |
| SP-COOH | 10:0 | 4173920.00 | 0.418 | m |
| 9:1 | 4742400.00 | 0.34 | 1.396855m |
| 8:2 | 4313660.00 | 0.236 | 1.830485m |
| 7:3 | 3774990.00 | 0.166 | 2.277403m |
| 6:4 | 2899810.00 | 0.121 | 2.400028m |
| 5:5 | 2338910.00 | 0.081 | 2.891749m |
| 4:6 | 1631480.00 | 0.056 | 2.917601m |
| 3:7 | 1218210.00 | 0.044 | 2.772692m |
| 2:8 | 715885.23 | 0.04 | 1.79232m |
| 1:9 | 659233.72 | 0.042 | 1.57189m |
| SP-Cellulose | 10:0 | 4166460.00 | 0.64 | 0.651958m |
| 9:1 | 5951370.00 | 0.556 | 1.071949m |
| 8:2 | 5661670.00 | 0.426 | 1.330966m |
| 7:3 | 4936690.00 | 0.319 | 1.549806m |
| 6:4 | 3927020.00 | 0.23 | 1.709887m |
| 5:5 | 2929000.00 | 0.17 | 1.725451m |
| 4:6 | 3179420.00 | 0.134 | 2.376158m |
| 3:7 | 5374340.00 | 0.512 | 1.051205m |
| 2:8 | 8981930.00 | 0.74 | 1.215542m |
| 1:9 | 8240470.00 | 0.68 | 1.213599m |

1. **UV-Vis measurements of the recyclability of the SP-Cellulose colloidal particles in ethanol.**



**Fig. S7** UV-Vis measurements of the recyclability of the SP-Cellulose colloidal particles in ethanol.

**Reference**

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