

## **Grayscale Photomasks Enable Noncontact Optical Patterning of Hydroxypropyl Cellulose Gels for Dynamic Art**

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This Supplementary Information includes:

Fig. S1 to S9

Tables S1 to S8

Other supplementary materials include the following:

Movies S1

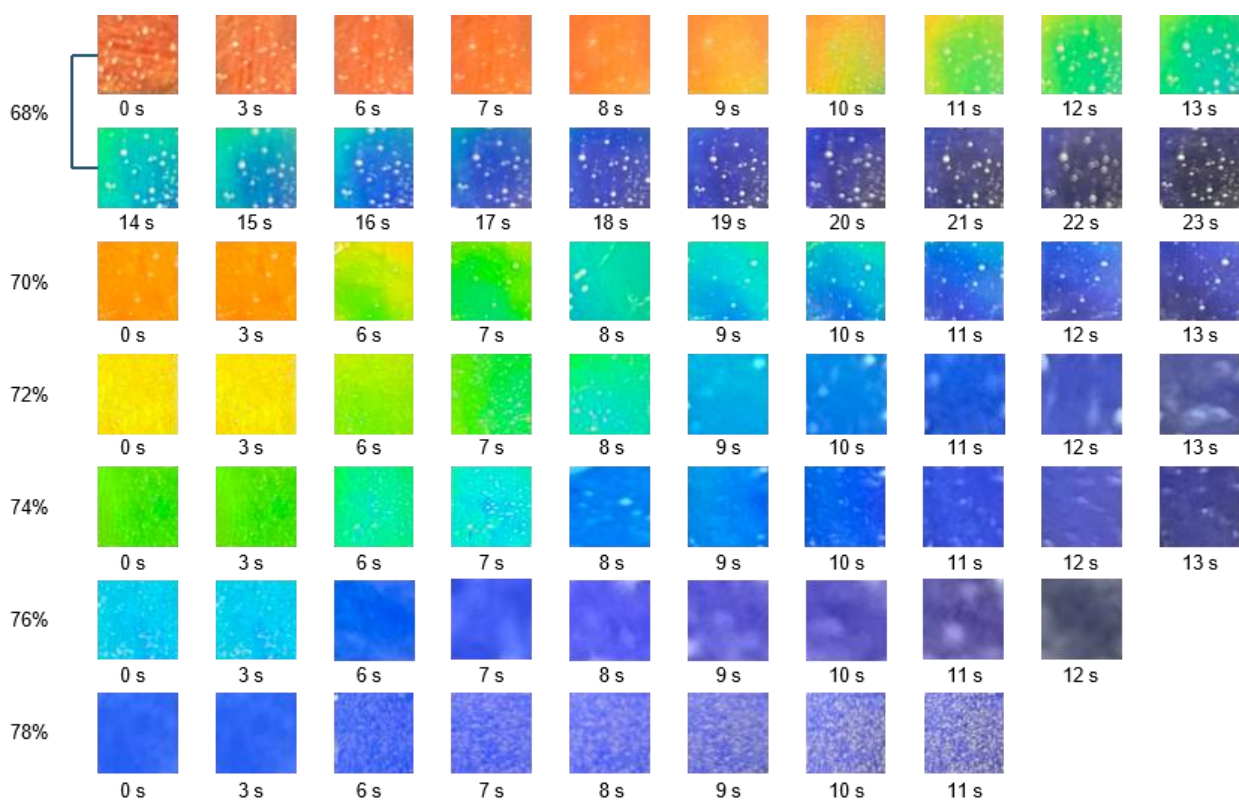


Figure S1. The color images of 68 wt% to 78 wt% AM-HPC under UV irradiation (10 mW/cm<sup>2</sup>) at different time intervals.

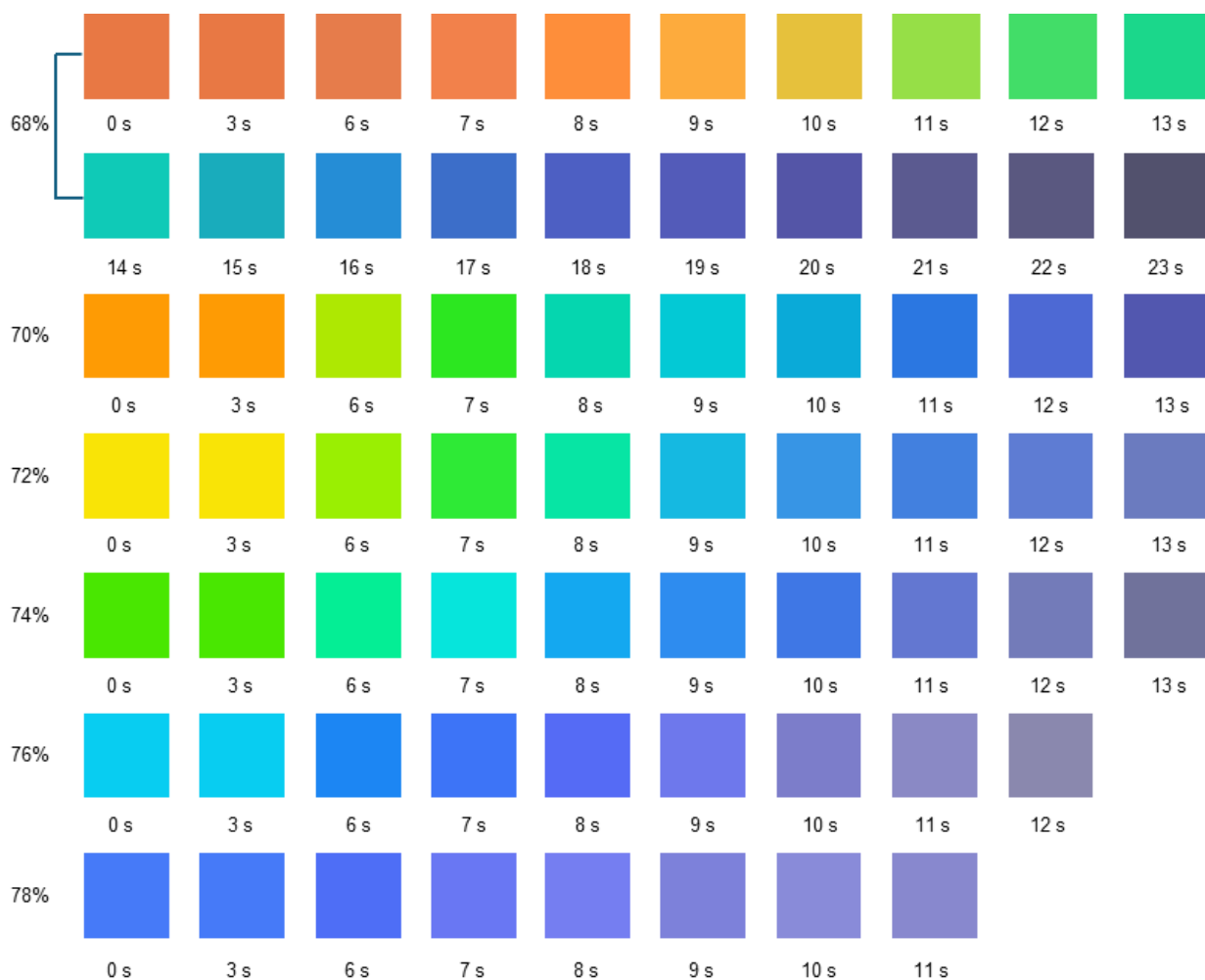


Figure S2. The mean color images of 68 wt% to 78 wt% AM-HPC under UV irradiation (10 mW/cm<sup>2</sup>) at different time intervals.

Table S1. Evolution of camera derived RGB for 68 wt% AM-HPC as a function of UV irradiation time.

| <b>UV-Time (s)</b> | <b>R</b> | <b>G</b> | <b>B</b> | <b><math>\lambda</math> (nm)</b> |
|--------------------|----------|----------|----------|----------------------------------|
| <b>0</b>           | 232      | 120      | 68       | 662                              |
| <b>3</b>           | 232      | 120      | 68       | 662                              |
| <b>6</b>           | 230      | 124      | 75       | 662                              |
| <b>7</b>           | 242      | 129      | 75       | 662                              |
| <b>8</b>           | 254      | 142      | 58       | 658                              |
| <b>9</b>           | 253      | 171      | 61       | 649                              |
| <b>10</b>          | 230      | 193      | 60       | 631                              |
| <b>11</b>          | 150      | 223      | 71       | 606                              |
| <b>12</b>          | 66       | 221      | 104      | 556                              |
| <b>13</b>          | 27       | 215      | 139      | 523                              |
| <b>14</b>          | 15       | 202      | 183      | 512                              |
| <b>15</b>          | 25       | 172      | 188      | 503                              |
| <b>16</b>          | 37       | 141      | 214      | 496                              |
| <b>17</b>          | 60       | 110      | 201      | 484                              |
| <b>18</b>          | 77       | 95       | 195      | 474                              |
| <b>19</b>          | 83       | 91       | 185      | 466                              |
| <b>20</b>          | 84       | 85       | 167      | 463                              |
| <b>21</b>          | 91       | 90       | 144      | 460                              |
| <b>22</b>          | 90       | 88       | 128      | 459                              |
| <b>23</b>          | 82       | 81       | 109      | 458                              |

Table S2. Evolution of camera derived RGB for 70 wt% AM-HPC as a function of UV irradiation time.

| <b>UV-Time (s)</b> | <b>R</b> | <b>G</b> | <b>B</b> | <b><math>\lambda</math> (nm)</b> |
|--------------------|----------|----------|----------|----------------------------------|
| <b>0</b>           | 254      | 155      | 4        | 628                              |
| <b>3</b>           | 254      | 155      | 4        | 628                              |
| <b>6</b>           | 174      | 232      | 2        | 567                              |
| <b>7</b>           | 44       | 231      | 32       | 533                              |
| <b>8</b>           | 5        | 214      | 175      | 507                              |
| <b>9</b>           | 3        | 201      | 213      | 498                              |
| <b>10</b>          | 10       | 170      | 216      | 491                              |
| <b>11</b>          | 43       | 119      | 225      | 477                              |
| <b>12</b>          | 77       | 105      | 212      | 468                              |
| <b>13</b>          | 82       | 87       | 175      | 462                              |

Table S3. Evolution of camera derived RGB for 72 wt% AM-HPC as a function of UV irradiation time.

| <b>UV-Time (s)</b> | <b>R</b> | <b>G</b> | <b>B</b> | <b><math>\lambda</math> (nm)</b> |
|--------------------|----------|----------|----------|----------------------------------|
| <b>0</b>           | 249      | 228      | 6        | 590                              |
| <b>3</b>           | 249      | 228      | 6        | 590                              |
| <b>6</b>           | 154      | 239      | 2        | 562                              |
| <b>7</b>           | 46       | 234      | 54       | 529                              |
| <b>8</b>           | 7        | 229      | 164      | 509                              |
| <b>9</b>           | 21       | 185      | 225      | 492                              |
| <b>10</b>          | 55       | 149      | 229      | 482                              |
| <b>11</b>          | 66       | 128      | 223      | 476                              |
| <b>12</b>          | 94       | 124      | 211      | 470                              |
| <b>13</b>          | 107      | 123      | 191      | 468                              |

Table S4. Evolution of camera derived RGB for 74 wt% AM-HPC as a function of UV irradiation time.

| <b>UV-Time (s)</b> | <b>R</b> | <b>G</b> | <b>B</b> | <b><math>\lambda</math> (nm)</b> |
|--------------------|----------|----------|----------|----------------------------------|
| <b>0</b>           | 73       | 231      | 1        | 546                              |
| <b>3</b>           | 73       | 231      | 1        | 546                              |
| <b>6</b>           | 4        | 238      | 149      | 511                              |
| <b>7</b>           | 6        | 229      | 220      | 501                              |
| <b>8</b>           | 20       | 168      | 240      | 487                              |
| <b>9</b>           | 46       | 140      | 239      | 479                              |
| <b>10</b>          | 63       | 119      | 229      | 473                              |
| <b>11</b>          | 99       | 119      | 209      | 467                              |
| <b>12</b>          | 115      | 123      | 185      | 465                              |
| <b>13</b>          | 112      | 114      | 155      | 462                              |

Table S5. Evolution of camera derived RGB for 76 wt% AM-HPC as a function of UV irradiation time.

| <b>UV-Time (s)</b> | <b>R</b> | <b>G</b> | <b>B</b> | <b><math>\lambda</math> (nm)</b> |
|--------------------|----------|----------|----------|----------------------------------|
| <b>0</b>           | 8        | 205      | 241      | 494                              |
| <b>3</b>           | 8        | 205      | 241      | 494                              |
| <b>6</b>           | 28       | 134      | 243      | 480                              |
| <b>7</b>           | 61       | 116      | 247      | 472                              |
| <b>8</b>           | 85       | 107      | 245      | 466                              |
| <b>9</b>           | 110      | 120      | 236      | 463                              |
| <b>10</b>          | 124      | 125      | 202      | 461                              |

|           |     |     |     |     |
|-----------|-----|-----|-----|-----|
| <b>11</b> | 138 | 137 | 197 | 459 |
| <b>12</b> | 138 | 136 | 174 | 458 |

Table S6. Evolution of camera derived RGB for 78 wt% AM-HPC as a function of UV irradiation time.

| UV-Time (s) | R   | G   | B   | $\lambda$ (nm) |
|-------------|-----|-----|-----|----------------|
| <b>0</b>    | 70  | 122 | 248 | 472            |
| <b>3</b>    | 70  | 122 | 248 | 472            |
| <b>6</b>    | 78  | 110 | 246 | 468            |
| <b>7</b>    | 105 | 119 | 243 | 464            |
| <b>8</b>    | 117 | 126 | 241 | 463            |
| <b>9</b>    | 125 | 129 | 218 | 462            |
| <b>10</b>   | 137 | 139 | 217 | 461            |
| <b>11</b>   | 136 | 136 | 206 | 460            |

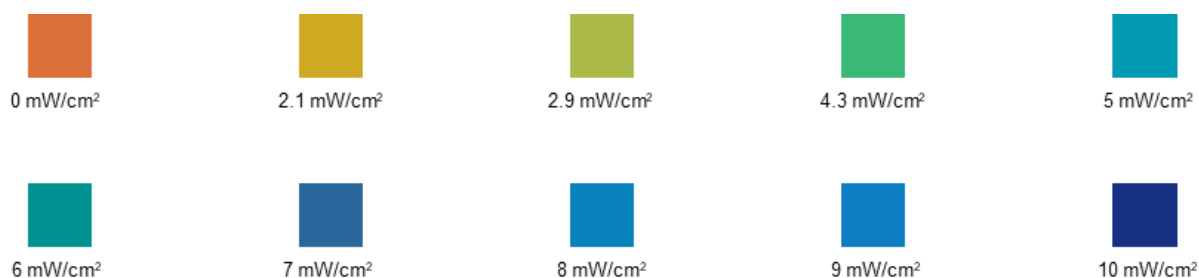


Figure S3. Mean-color images of the 68 wt% AM-HPC gel under UV irradiation at different power densities.

Table S7. Evolution of RGB values and camera-derived apparent wavelength for the 68 wt% AM-HPC gel as a function of UV power density.

| UV-Power (mW/cm²) | R   | G   | B   | $\lambda$ (nm) |
|-------------------|-----|-----|-----|----------------|
| <b>0</b>          | 219 | 111 | 56  | 655            |
| <b>2.1</b>        | 206 | 169 | 33  | 604            |
| <b>2.9</b>        | 172 | 186 | 73  | 575            |
| <b>4.3</b>        | 57  | 185 | 117 | 511            |
| <b>5</b>          | 3   | 154 | 180 | 486            |

|    |    |     |     |     |
|----|----|-----|-----|-----|
| 6  | 1  | 147 | 145 | 489 |
| 7  | 41 | 103 | 156 | 483 |
| 8  | 7  | 129 | 186 | 483 |
| 9  | 12 | 125 | 193 | 483 |
| 10 | 23 | 48  | 130 | 474 |

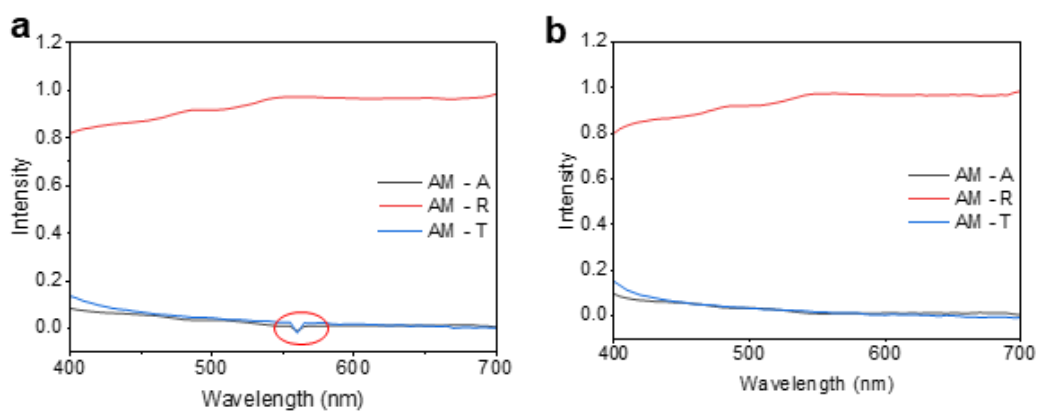


Figure S4. Transmission (T), reflection (R), and absorption (A) spectra of the photoinitiator system (a) before and (b) after UV irradiation.

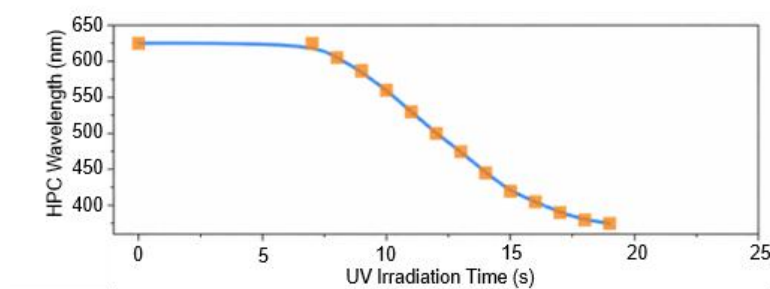


Figure S5. Peak wavelength extracted from the AM-HPC reflection spectrum as a function of UV irradiation time for the 68 wt% AM-HPC gel. The wavelength was determined from the position of the reflection peak.

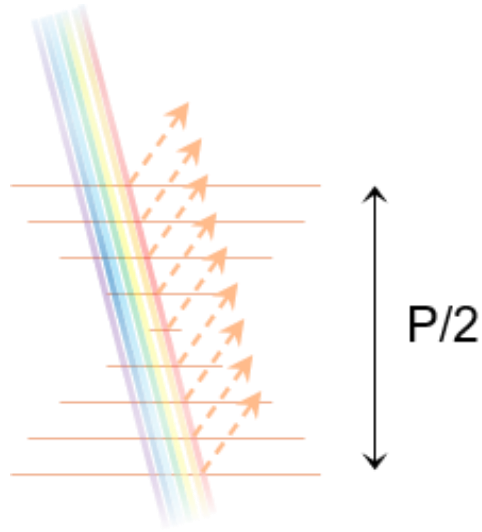


Figure S6. Schematic of the cholesteric director modulation in the AM-HPC gel. The full cholesteric pitch  $P/2$  corresponds to a  $180^\circ$  director rotation. For light propagating along the helical axis at normal incidence, the central selective-reflection wavelength is  $\lambda_0 \approx \bar{n}P$ , where  $\bar{n}$  is the average reflection index.

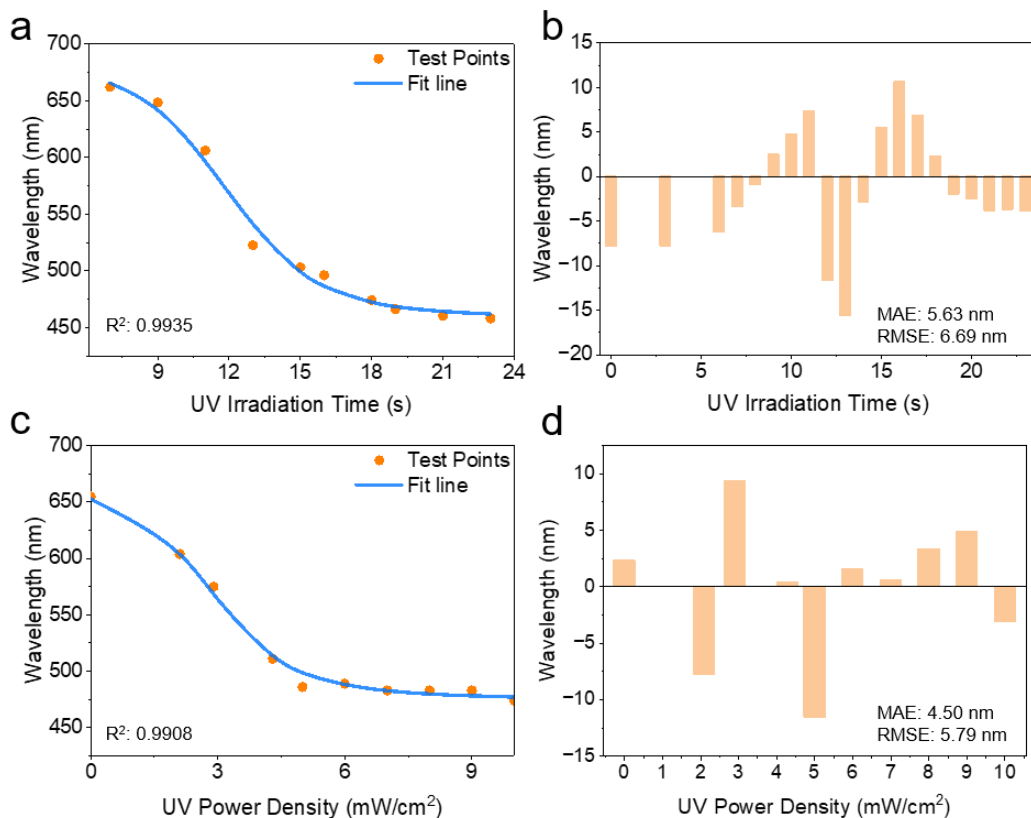


Figure S7. Four parameter logistic modeling of UV regulated structural color in AM-HPC photonic gels. (a) Fitting of the relationship between wavelength and UV irradiation time; (b) Mean absolute error and root mean square error of the wavelength and UV irradiation time fitting; (c) fitting of the relationship between wavelength and UV power density; (d) Mean absolute error and root mean square error of the wavelength and UV power density fitting.

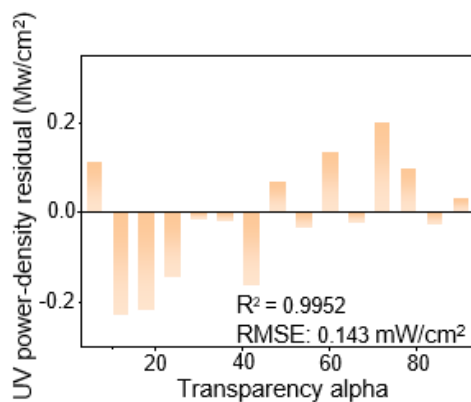


Figure S8. Fitting accuracy of the Monotonic model. Transparency alpha ( $\alpha$ ) is an 8-bit grayscale value from 0 to 255, where  $\alpha = 0$  gives maximum UV transmission and increasing  $\alpha$  reduces transmitted UV intensity.  $R^2$  and RMSE were calculated on held-out test points

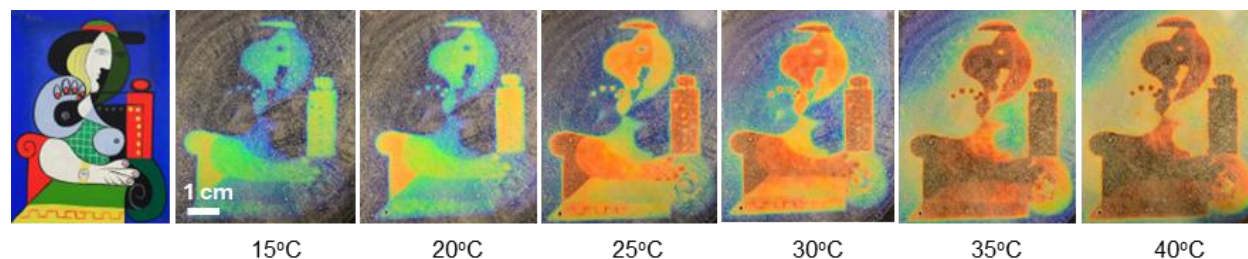


Figure S9. Temperature-responsive reconstruction of *Woman with a Watch* by Pablo Picasso enabled by programmable structural color.

Table S8. Formulations of AM-HPC gels.

| Sample | HPC (g) | AM (g) | MBA (g) | HMPP (g) | Water (g) |
|--------|---------|--------|---------|----------|-----------|
| 68%    | 7       | 0.7    | 0.07    | 0.07     | 2.45      |
| 70%    | 7       | 0.7    | 0.07    | 0.07     | 2.16      |
| 72%    | 7       | 0.7    | 0.07    | 0.07     | 1.88      |
| 74%    | 7       | 0.7    | 0.07    | 0.07     | 1.62      |
| 76%    | 7       | 0.7    | 0.07    | 0.07     | 1.37      |
| 78%    | 7       | 0.7    | 0.07    | 0.07     | 1.14      |