Supporting Information:

Time-Resolved Keto-Enol Tautomerization of the Medicinal Pigment Curcumin

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S1 MATLAB Script for the Determination of the Rate Constant of Tautomerization of Curcumin

The script used for data analysis according to the rate equations in manuscript is shown in the following:

```matlab
1   function diff=CD3OD(x,t1,NorH)
2   % This script is written for curcumin in deuterated methanol.
3   dt=0.0005;              % time interval of the fitiing
4   k1=x(1)*2000;          % larger than k2 by a factor of 2000
5                          % (see Section 5.4.2)
6   k2=x(1);              % rate of tautomerisation
7   k3=x(1)*K;           % multiply k2 by the equilibrium
8                         % constant,K,(see Table 5.1).
9   t(1,1)=0;
10  A(1,1)=NorH(1);
11  B(1,1)=0;
12  C(1,1)=0;
13  D(1,1)=0;
14  E(1,1)=0;
15  od(1,1)=2267;          % number of OH with respect to curcumin,
16                         % 227 for Acetone and Acetonitrile.
17  oh(1,1)=5;             % number of OD with respect to curcumin,
18                         % 0.2 for Acetone and Acetonitrile.
19      for i=2:(t1(end)/dt),
20          t(i,1) = (i-1)*dt;
21
22          A(i,1) = A(i-1,1) + (-k1*A(i-1,1)*od(i-1,1) + ...
                 (k1*B(i-1,1)*oh(i-1,1)))*dt;
23          B(i,1) = B(i-1,1) + ((k1*A(i-1,1)*od(i-1,1)) + (-k2*B(i-1,1)) + ...
                 (k3*C(i-1,1)) + (-k1*B(i-1,1)*oh(i-1,1)))*dt;
```

```matlab
24
25          od(i,1)= od(i-1,1) + ((-k1*A(i-1,1)*od(i-1,1)) + ...
                (k1*B(i-1,1)*oh(i-1,1)))*dt;
26          oh(i,1)= oh(i-1,1) + ((k1*A(i-1,1)*od(i-1,1)) + ...
                (-k1*B(i-1,1)*oh(i-1,1)))*dt;
27
28          C(i,1) = C(i-1,1) + ((k2*B(i-1,1)) + (-k3*C(i-1,1)) + ...
                (-k3*C(i-1,1)) + (k2*D(i-1,1)))*dt;
29          D(i,1) = D(i-1,1) + ((k3*C(i-1,1)) + (-k2*D(i-1,1)) + ...
                (-k1*D(i-1,1)*od(i-1,1)) + (k1*E(i-1,1)*oh(i-1,1)))*dt;
30          E(i,1) = E(i-1,1) + ((k1*D(i-1,1)*od(i-1,1)) + ...
                (-k1*E(i-1,1)*oh(i-1,1)))*dt;
31
32          od(i,1)= od(i,1) + ((-k1*D(i-1,1)*od(i,1)) + ...
                (k1*E(i-1,1)*oh(i,1)))*dt;
33          oh(i,1)= oh(i,1) + ((k1*D(i-1,1)*od(i,1)) + ...
                (-k1*E(i-1,1)*oh(i,1)))*dt;
34     end
35 new_NorH=interp1(t1,NorH,t);
36 new_NorH(isnan(new_NorH))=0;
37 diff=(A+B)-new_NorH;     %(A+B) is the raw data and
38                         % new_NorH is the fitting
```

S2   Femtosecond fluorescence upconversion spectroscopy

For the femtosecond fluorescence upconversion measurements, a methanol or methanol-d_4 solution with a concentration of approximately $90\,\mu\text{M}$ was used. All measurements were performed on freshly prepared samples at room temperature using a quartz cuvette with a 2-mm path length. The absorbance of the solution was below 0.1 to avoid the inner filter effect. The laser source was a Ti:sapphire mode-locked oscillator (Spectra Physics, Tsunami) pumped by a 8 W Nd:YVO$_4$ diode laser (Spectra Physics, Millennia Pro-s). This output

seeded a Ti:sapphire regenerative amplifier (Spectra-Physics, Spitfire Pro XP) pumped by a 20 W Q-switched Nd:YLF laser (Spectra-Physics, Empower). The output of the amplifier was centred at 800 nm with a repetition rate of 1 kHz and pulse duration of 100 fs, which was then split into excitation and gate beams. Frequency-doubled pulses (400 nm) at 0.05 mW were used to excite the sample and fluorescence was collected with a plano-convex lens. The gate pulse and fluorescence were then focussed onto a 0.4 mm type-I BBO crystal to generate sum frequency signals, which were detected by a photomultiplier tube attached to a monochromator. The fluorescence upconversion decays of curcumin in methanol or methanol-d_4 was monitored at 500 nm.

S3 Density Functional Theory

Output files for all DFT calculations are downloadable from: `https://zenodo.org/doi/10.5281/zenodo.7781208`.
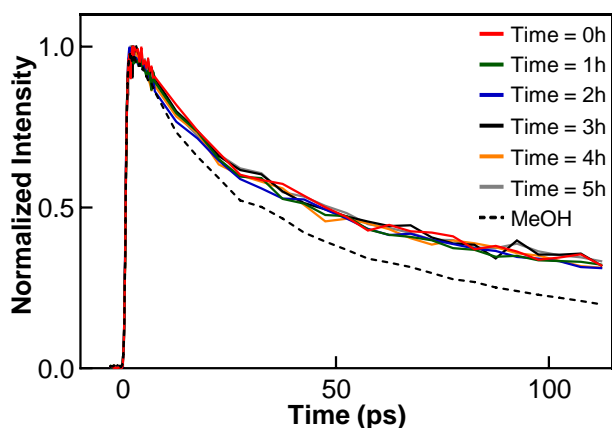

Figure S1: Fluorescence upconversion spectra of curcumin in methanol (dashed) and methanol-d_4 (solid) at ambient temperature over 5 hours.

Table S1: Energies of keto and enol isomers of curcumin and the cisoid transition state, calculated with and without implicit solvent.

$n(\mathbf{H_2O})$	$E_{\mathbf{diketo}}$ (a.u.)	$E_{\mathbf{TS}}$ (a.u.)	$E_{\mathbf{enol}}$ (a.u.)
SCRF=none			
0	-1263.658604	-1263.576714	-1263.667757
1	-1340.111225	-1340.053458	-1340.116163
2	-1416.559892	-1416.514889	-1416.568765
3	-1493.013554	-1492.975651	-1493.008934
SCRF=water			
0	-1263.680183	-1263.599624	-1263.687453
1	-1340.137143	-1340.081313	-1340.141222
2	-1416.593135	-1416.54752	-1416.595024
3	-1493.049188	-1493.008193	-1493.039239
SCRF=methanol			
0	-1263.679422	-1263.598959	-1263.686809
1	-1340.136501	-1340.080640	-1340.140475
2	-1416.591835	-1416.546346	-1416.594930
3	-1493.048010	-1493.006595	-1493.038137
SCRF=acetone			
0	-1263.678703	-1263.598416	-1263.686175
1	-1340.135082	-1340.080141	-1340.139768
2	-1416.590239	-1416.544856	-1416.593916
3	-1493.047174	-1493.005243	-1493.037089
SCRF=acetonitrile			
0	-1263.679526	-1263.599053	-1263.686903
1	-1340.136556	-1340.080733	-1340.140578
2	-1416.592076	-1416.546569	-1416.595114
3	-1493.048010	-1493.006594	-1493.038137
SCRF=methanol $n(\mathbf{CH_3OH})$			
1	-1379.416357	-1379.363974	-1379.419948
2	-1495.153491	-1495.111352	-1495.155597
3	-1610.889848	-1610.852297	-1610.891554