Electronic Supplementary Information (ESI)

Effect of Crystal Growth Kinetics on the Formation of Liquid Inclusions in Tetramethylpyrazine Crystals

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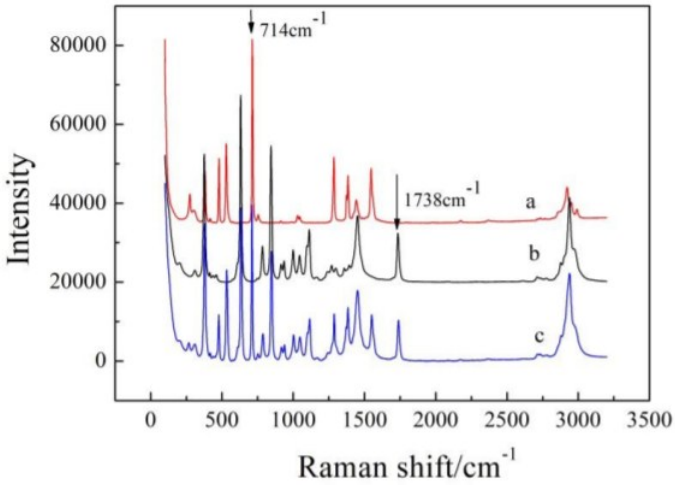

Figure S1. Micro-Raman spectra of (a) TMP crystals, (b) pure ethyl acetate solvent, and (c) saturated solution of TMP in ethyl acetate.

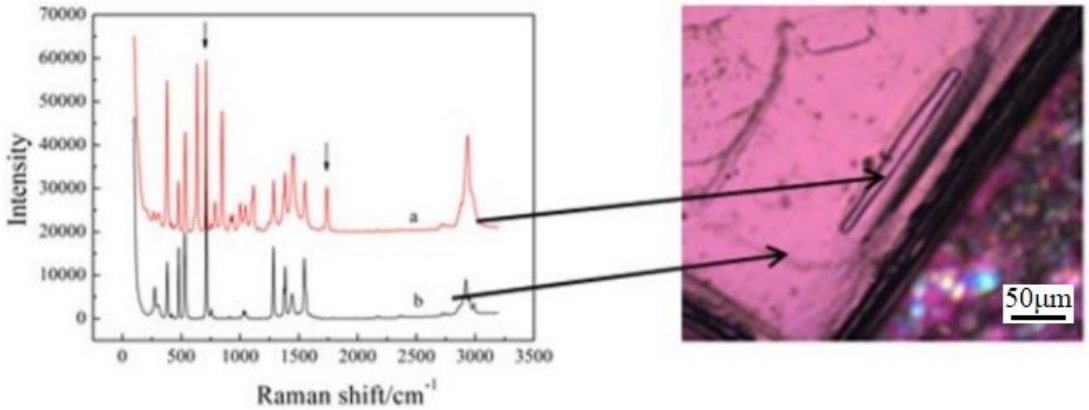

Figure S2. Micro-Raman spectra of different regions inside TMP crystal: (a) liquid inclusion; (b) bulk crystal.

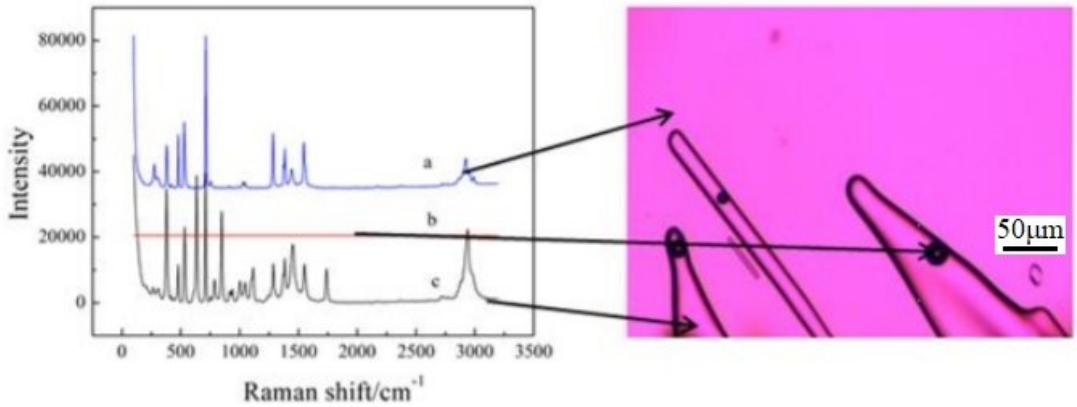

Figure S3. Micro-Raman spectra of different regions inside TMP crystal: (a) bulk crystal; (b) isolated bubbles; (c) fluid inclusion.

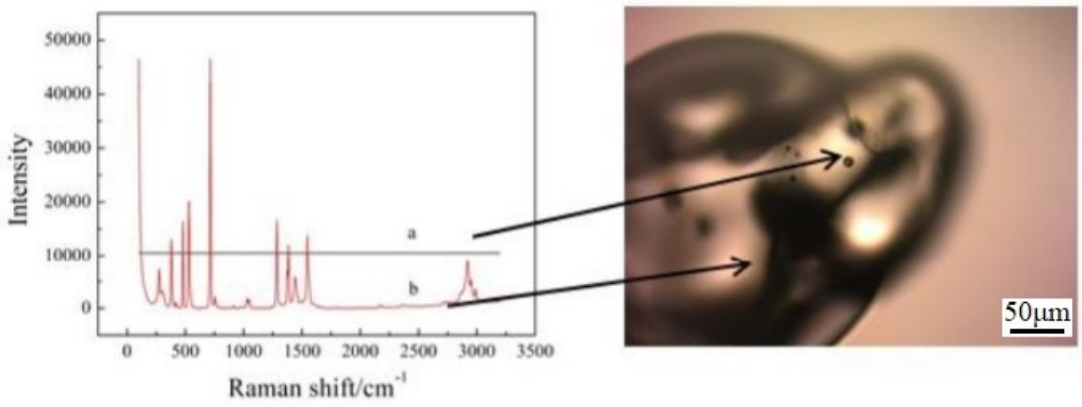

Figure S4. Micro-Raman spectra of different regions inside TMP crystal with gas inclusions: (a) isolated bubbles; (b) bulk crystal.

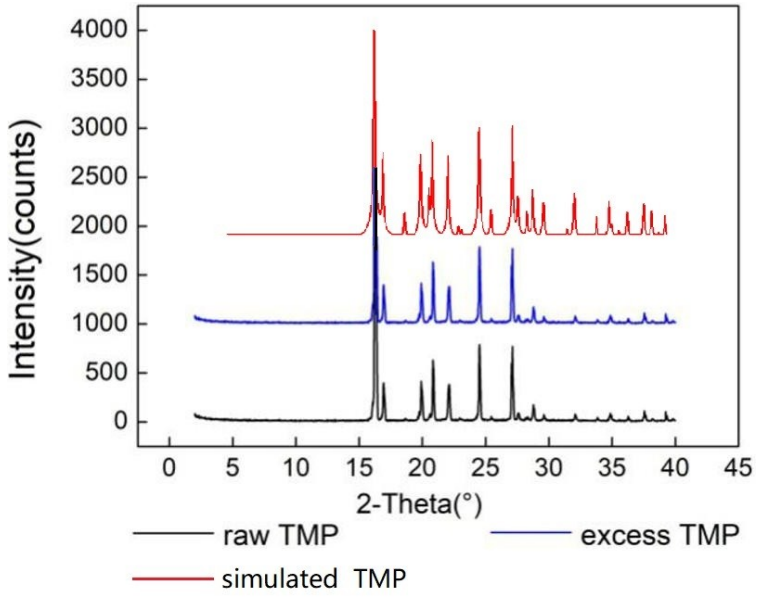

Figure S5. PXRD patterns of TMP raw material, excess TMP crystals from ethyl acetate, and the simulated orthorhombic anhydrous crystal form from Cambridge Structural Database (CSD).

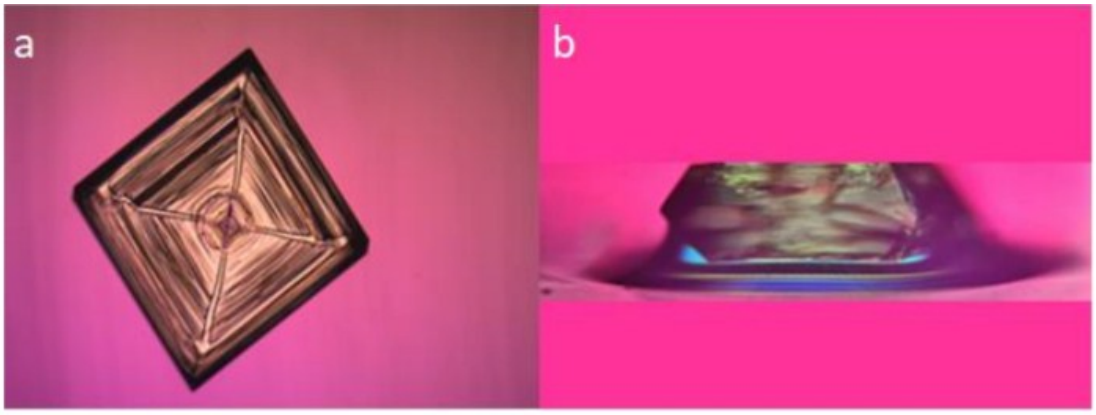

Figure S6. Single crystal of TMP: (a) top view; (b) side view.

Table S1. Solubility data (mole fraction) of TMP in four solvents at different temperatures.[1]

Solvent	283.15K	293.15K	303.15K
Ethyl acetate	0.1134	0.1595	0.2121
Ethanol	0.1098	0.1616	0.1957
Acetonitrile	0.0404	0.0588	0.0933
Isopropanol	0.0814	0.1151	0.1655

Table S2. Time-resolved single crystal growth data of TMP in ethyl acetate solution

β=1.05, t=10℃			β=1.05, t=20℃		
Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
4	656.606	704.265	84	871.004	821.961
82	723.470	764.800	139	916.301	873.440
205	815.972	851.366	173	937.548	905.100
327	907.112	915.146	227	992.386	961.920
434	975.047	971.205	395	1116.129	1102.708
533	1038.934	1020.232	624	1287.689	1285.187
663	1125.761	1091.279	706	1375.545	1354.091
703	1151.216	1101.221	907	1485.814	1500.700
864	1252.082	1190.535	962	1530.884	1542.989
1102	1401.087	1314.957	992	1540.255	1573.038
1204	1460.509	1382.427	1004	1559.539	1580.895
1304	1525.998	1447.393	1017	1564.282	1593.625
1474	1610.037	1541.732	1091	1608.825	1646.787
			1191	1665.165	1737.369
			1334	1799.133	1833.766
			1515	1964.282	1993.625
β=1.05, t=30℃			β=1.15, t=10℃		
Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
25	767.842	836.556	14	670.911	640.641
69	836.045	914.421	72	747.242	706.792
116	899.296	984.509	166	846.575	790.365
238	1059.848	1122.678	285	966.790	902.762
320	1162.225	1233.574	346	1028.289	957.484
395	1259.030	1325.499	467	1133.764	1051.098
509	1391.558	1479.167	656	1287.564	1200.303
711	1615.785	1705.039	776	1437.469	1335.322
825	1730.199	1813.976	819	1501.741	1409.035
944	1869.255	1937.667	1228	1787.272	1646.684
1033	1954.436	2022.984			
1173	2109.001	2166.594			
β=1.15, t=20℃			β=1.15, t=30℃		

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Table S2. (continued)

Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
3	751.115	849.837	2	725.432	739.717
63	818.672	951.271	27	812.275	815.307
123	903.219	1008.467	51	893.522	888.085
189	974.982	1074.291	95	1006.587	1016.135
954	1856.735	1896.103			
1179	2031.001	2120.988			
1244	2100.037	2207.686			
1285	2151.501	2264.138			
1347	2283.982	2460.749			

Table S3. Time-resolved single crystal growth data of TMP in different solutions with supersaturation β=1.05.

Ethanol, t=10℃			Ethanol, t=20℃		
Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
8	567.929	582.47	120	630.929	672.445
91	641.771	637.907	241	676.069	727.515
200	705.837	701.186	366	757.7800	790.096
279	749.114	747.323	482	826.213	851.965
472	847.669	855.812	614	923.836	919.664
741	989.721	1002.104	816	1052.116	1069.966
1129	1169.497	1207.697	1047	1246.670	1245.836
1377	1297.819	1317.596	1358	1499.549	1482.380
1532	1378.376	1384.288	1563	1649.328	1637.481
1632	1427.463	1432.817	1791	1826.999	1818.599
1844	1522.532	1515.729	1906	1922.079	1890.26
2031	1604.020	1583.119	2016	2005.182	1968.491
2403	1738.322	1702.058	2291	2186.665	2144.601
2619	1809.907	1761.680			
Acetonitrile, t=10℃			Acetonitrile, t=20℃		
Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
0	641.415	672.468	2	712.798	684.992
110	688.409	720.598	69	757.794	728.788
349	817.503	786.237	168	822.101	797.311
471	838.939	866.481	376	952.375	914.793
532	874.050	899.723	578	1045.691	1028.930
699	942.969	963.282	877	1214.903	1177.908
883	1022.142	1038.219	1144	1364.557	1313.575
998	1058.180	1083.182	1433	1524.841	1464.557

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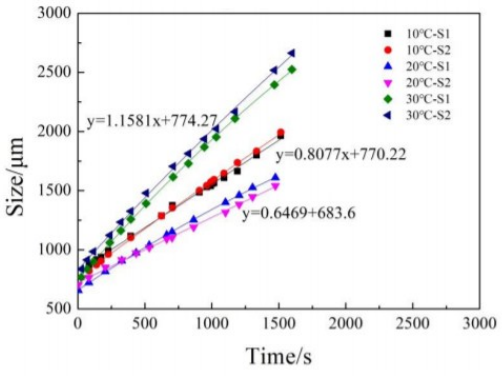
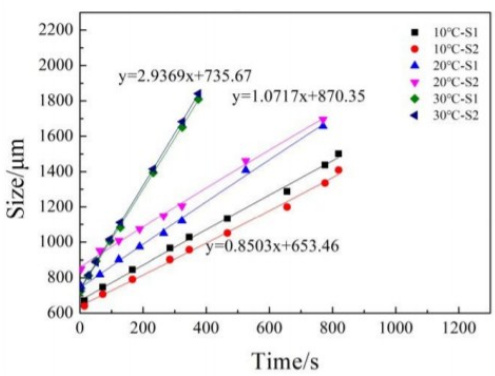
Table S3. (continued)

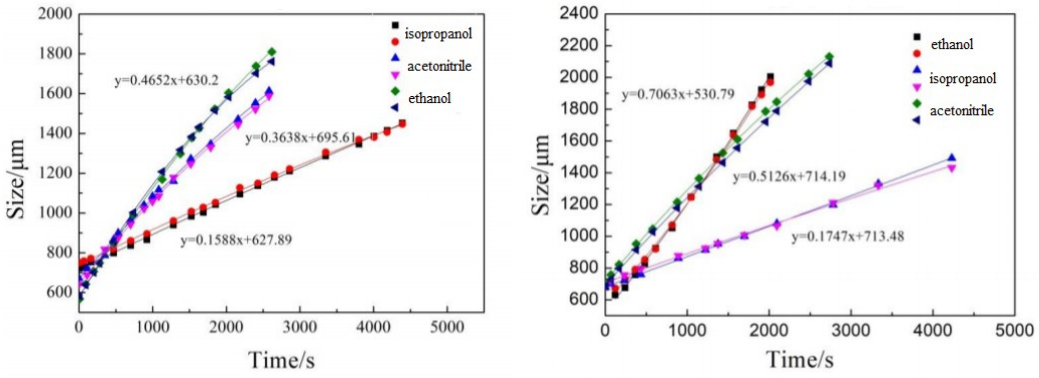
1084	1084.039	1117.023	1613	1609.706	1556.194
1285	1179.061	1159.795	1956	1786.718	1721.155
1787	1330.700	1346.333	2482	2021.841	1975.364
2159	1445.134	1471.498	2734	2131.169	2088.768
2395	1521.792	1552.810			
2580	1587.943	1613.262			
	Isopropanol, t=10℃			Isopropanol, t=20℃	
Time/s	Length of x axis/ μ m	Length of y axis/ μ m	Time/s	Length of x axis/ μ m	Length of y axis/ μ m
4	721.387	749.033	2	679.73	708.46
68	730.097	757.739	65	700.534	717.868
162	754.197	771.015	232	720.354	755.858
470	798.571	816.962	434	759.745	795.893
703	836.234	859.799	891	862.292	877.398
923	865.974	895.322	1223	914.185	924.081
1282	939.025	959.539	1375	951.836	952.549
1526	983.538	1006.982	1699	999.333	1007.771
1688	1002.806	1027.573	2095	1080.505	1065.79
1854	1042.203	1052.398	2782	1197.949	1210.921
2185	1095.170	1126.979	3332	1331.681	1320.318
2430	1137.172	1149.643	4229	1491.918	1431.546
2654	1179.519	1190.567			
2860	1210.926	1221.167			
3350	1286.917	1305.365			
3800	1346.716	1368.826			
4005	1385.943	1380.643			
4184	1414.914	1406.250			
4391	1452.350	1447.239			
4896	1501.785	1503.029			





(a) (b)

Figure S7. Growth rate of TMP crystal in ethyl acetate solution at different temperatures with β=1.05 (a) and with β=1.15 (b).



(a) (b)

Figure S8. Growth rate of TMP in different solvents at 10°C with β=1.05 (a) and at 20°C with β=1.05 (b).

Notes and references

1. Z. Nuoyang, L. Si, Y. Haiyan, L. Mengya, Y. Yang, T. Weiwei, *Journal of Chemical and Engineering Data*, 2019, **64(3)**, 995-1006.