Supplementary Information

Table S1

Chemical composition of experimental solutions and solids of solubility experiments. Sample: synthetic ACMC sample used for solubility experiments (see Table 1); Time: reaction time during the experimental run; pH: pH of the experimental solution; Alkalinity: alkalinity concentration of the experimental solution; $[Ca]_{aq}$, $[Mg]_{aq}$, $[Na]_{aq}$: measured Ca, Mg and Na concentration of the experimental solution; $[Mg]_{ACMC}$: Mg content of the ACMC solid; IAP_{ACMC}: ion activity product of the experimental solution calculated according to eq. 1.

Sample	Time min	pH	Alkalinity mM	$[Ca]_{aq}$ mM	$[Mg]_{aq}$ mM	$[Na]_{aq}$ mM	$[Mg]_{ACMC}$ mol%
ACC	0	8.30	104.2	0	28.6	99.3	0
	0.2	8.37	106.1	4.6	24.9	96.8	1.8
	2.3	8.41	105.0	4.9	26.4	105.1	2.1
	4.4	8.40	105.7	4.8	25.9	103.8	2.1
	6.4	8.40	104.6	4.9	25.8	103.4	2.2
	8.7	8.40	105.4	4.6	25.0	99.4	2.3
	12.5	8.41	104.4	4.5	25.1	102.7	2.3
ACMC_9	0	8.32	103.6	0	29.3	101.4	9.1
	0.2	8.47	105.6	3.9	27.8	100.7	10.4
	2.2	8.54	107.5	3.7	28.7	104.3	10.4
	4.6	8.54	106.8	3.7	28.0	103.3	10.4
	11.9	8.55	107.6	3.6	28.1	103.9	10.4
	16.1	8.56	106.1	3.7	28.3	103.8	10.6
	22.3	8.57	107.1	3.5	27.7	104.1	10.6
ACMC_15	0	8.40	103.5	0	30.2	103.6	14.9
	0.2	8.64	112.3	4.0	30.6	102.0	15.7
	1.7	8.66	111.2	3.5	30.7	101.6	15.7
	4.1	8.66	111.7	3.3	30.3	102.3	15.8
	6.3	8.66	110.8	3.3	30.9	104.2	15.5
	9.8	8.67	108.9	3.2	30.7	104.2	15.7
	14.0	8.67	108.8	3.1	30.3	101.4	15.8
	21.2	8.67	108.8	3.0	29.8	101.9	16.0
	28.4	8.68	108.8	3.0	30.1	102.7	16.0
	35.7	8.69	109.8	3.1	30.4	103.6	15.9
ACMC_22	0	8.33	103.3	0.0	25.6	99.0	21.9
	0.2	8.60	140.9	2.5	31.0	-	21.5
	4.6	8.66	115.9	2.9	32.0	98.4	21.2
	7.8	8.67	115.9	2.9	30.8	97.8	20.8
	12.1	8.68	116.5	2.7	31.1	98.5	21.0
	17.9	8.69	115.0	2.9	32.7	98.1	21.9
	27.5	8.70	116.3	2.6	30.4	97.4	21.3
	44.7	8.71	115.3	2.7	32.3	103.7	21.2
ACMC_31	0.0	8.32	104.8	0	27.0	106.7	30.8
	0.2	8.43	124.5	2.5	35.9	106.5	29.4
	2.0	8.89	126.9	2.5	36.0	103.0	30.4
	4.0	8.91	128.1	2.0	34.2	101.3	29.0
	6.1	8.92	124.9	2.1	36.2	104.9	28.2
	8.8	8.92	128.4	2.2	37.3	105.6	29.2
	11.9	8.93	128.4	2.3	40.1	102.1	30.6
	14.2	8.94	129.8	2.5	39.4	103.8	29.3
	18.6	8.94	125.3	2.5	40.4	106.6	28.9

	35.7	8.95	124.5	2.1	38.7	102.5	28.9
ACMC_39	0	8.32	104.7	0	28.8	101.5	39.4
	0.2	8.87	125.1	2.3	39.1	101.9	38.2
	5.2	9.01	133.6	2.0	40.8	102.2	37.2
	8.2	9.02	133.7	1.8	39.9	102.2	37.4
	11.3	9.02	132.8	1.8	35.5	102.7	37.7
	14.9	9.02	132.9	1.7	35.2	102.7	37.2
	19.1	9.02	131.8	1.7	36.4	101.7	37.7
	39.1	9.02	133.2	1.8	37.6	102.0	37.1
ACMC_53	0	8.32	103.1	0	30.7	102.9	53.4
	0.2	8.95	140.5	2.1	47.3	104.7	51.8
	1.7	9.11	141.7	1.6	47.9	101.5	51.2
	3.9	9.14	143.3	1.6	49.4	103.7	51.2
	5.7	9.14	143.8	1.6	49.9	104.6	51.4
	10.4	9.15	143.9	1.5	49.1	103.7	50.9
	13.5	9.16	144.1	1.5	48.5	101.8	50.4
	18.6	9.16	143.3	1.5	48.5	103.5	51.6
ACMC_80	0.0	8.33	104.0	0.0	28.3	100.9	79.5
	0.2	9.01	154.7	1.4	48.6	98.4	78.6
	1.8	9.23	159.4	1.0	51.5	99.8	78.3
	3.9	9.25	162.0	0.9	52.2	100.5	78.5
	5.7	9.26	160.6	0.8	52.1	100.2	78.4
	7.8	9.27	161.4	0.8	51.8	100.1	78.8
AMC	0	8.33	103.1	0	28.5	102.7	100
	0.2	9.31	189.4	0	67.78	102.3	100
	1.9	9.39	181.4	0	61.6	100.1	100
	3.8	9.39	175.7	0	59.8	102.4	100

Table S2

Input data for PhreeqC calculations and selected output data of experimental solutions at chemical steady state conditions (> 2 min). Sample: synthetic ACMC sample used for solubility experiments (see Table 1); Time: reaction time during the experimental run; Alkalinity: alkalinity concentration; $[Ca]_{aq}$, $[Mg]_{aq}$, $[Na]_{aq}$: measured Ca, Mg and Na concentration; $[Cl]_{aq}$: Cl concentration given by the $MgCl_2$ added in the initial experimental solution ($[Cl]_{aq}$ = 2* initial $[Mg]_{aq}$; see Table 1); I: ionic strength; charge: electrical charge balance; %Err: percentage error based on the charge imbalance (100*(Cat-An)/(Cat+An)); $p_{CO2(g)}$: logarithm of internal CO_2 partial pressure; $log(aCO_3^{2-})$, $log(aCa^{2+})$, $log(aCa^{2+})$: activities of Ca^{2+}, Mg^{2+} and CO_3^{2-} ions; $[Mg]_{ACMC}$: Mg content of the sampled ACMC solid; IAP_{ACMC}: ion activity product of the experimental solution calculated according to eq. 1.

Sample	Time min	pH	Alk. mM	$[Ca]_{aq}$ mM	$[Mg]_{aq}$ mM	$[Na]_{aq}$ mM	$[Cl]_{aq}$ mM	I	charge	%Err	$p_{CO2(g)}$	$log(aCO_3^{2-})$	$log(aCa^{2+})$	$log(aMg^{2+})$	$[Mg]_{ACMC}$ mol%	$log(IAP_{ACMC})$
ACC	2.3	8.41	105.0	4.9	26.4	105.1	57.1	0.17	5.6E-03	1.9	-1.81	-3.14	-3.07	-2.24	2.1	-6.19
	4.4	8.40	105.7	4.8	25.9	103.8	57.1	0.17	2.4E-03	0.8	-1.79	-3.14	-3.08	-2.24	2.1	-6.20
	6.4	8.40	104.6	4.9	25.8	103.4	57.1	0.17	3.1E-03	1.1	-1.80	-3.15	-3.07	-2.24	2.2	-6.20
	8.7	8.40	105.4	4.6	25.0	99.4	57.1	0.16	-3.9E-03	-1.4	-1.79	-3.14	-3.09	-2.26	2.3	-6.21
	12.5	8.41	104.4	4.5	25.1	102.7	57.1	0.17	4.0E-04	0.1	-1.81	-3.14	-3.10	-2.26	2.3	-6.22
Average	-	*8.40*	*105.0*	*4.7*	*25.6*	*102.9*	*57.1*	*0.17*	-	-	*-1.80*	*-3.14*	*-3.08*	*-2.25*	*2.2*	*-6.20*
±2δ	-	*±0.01*	*±1.1*	*±0.04*	*±1.2*	*±4.3*	-	*±0.01*	-	-	*±0.02*	*±0.01*	*±0.03*	*±0.02*	±0.2	*±0.02*
ACMC_9	2.2	8.54	107.5	3.7	28.7	104.3	58.6	0.17	3.0E-03	1.0	-1.95	-3.02	-3.21	-2.22	10.4	-6.13
	4.6	8.54	106.8	3.7	28.0	103.3	58.6	0.17	1.3E-03	0.4	-1.95	-3.02	-3.21	-2.23	10.4	-6.13
	11.9	8.55	107.6	3.6	28.1	103.9	58.6	0.17	1.1E-03	0.4	-1.96	-3.01	-3.23	-2.23	10.4	-6.14
	16.1	8.56	106.1	3.7	28.3	103.8	58.6	0.17	3.1E-03	1.1	-1.98	-3.01	-3.21	-2.22	10.6	-6.11
	22.3	8.57	107.1	3.5	27.7	104.1	58.6	0.17	8.0E-04	0.3	-1.99	-2.99	-3.24	-2.23	10.6	-6.12
Average	-	*8.55*	*107.0*	*3.6*	*28.2*	*103.9*	*58.6*	*0.17*	-	-	*-1.97*	*-3.01*	*-3.22*	*-2.23*	*10.5*	*-6.13*
±2δ	-	*±0.03*	*±1.2*	*±0.2*	*±0.7*	*±0.8*	-	-	-	-	*±0.04*	*±0.02*	*±0.03*	*±0.01*	±0.2	*±0.02*
ACMC_15	1.7	8.66	111.2	3.5	30.7	101.6	60.3	0.17	-1.5E-03	-0.5	-2.08	-2.91	-3.27	-2.21	15.7	-6.01
	4.1	8.66	111.7	3.3	30.3	102.3	60.3	0.17	-2.5E-03	-0.9	-2.08	-2.91	-3.29	-2.21	15.8	-6.03
	6.3	8.66	110.8	3.3	30.9	104.2	60.3	0.17	1.5E-03	0.5	-2.08	-2.91	-3.29	-2.20	15.5	-6.03
	9.8	8.67	108.9	3.2	30.7	104.2	60.3	0.17	2.8E-03	1.0	-2.10	-2.91	-3.30	-2.20	15.7	-6.04
	14.0	8.67	108.8	3.1	30.3	101.4	60.3	0.17	-9.0E-04	-0.3	-2.10	-2.91	-3.32	-2.21	15.8	-6.06
	21.2	8.67	108.8	3.0	29.8	101.9	60.3	0.17	-1.6E-03	-0.6	-2.10	-2.91	-3.33	-2.22	16.0	-6.06
	28.4	8.68	108.8	3.0	30.1	102.7	60.3	0.17	-2.0E-04	-0.1	-2.11	-2.90	-3.33	-2.21	16.0	-6.05
	35.7	8.69	109.8	3.1	30.4	102.4	60.3	0.17	-7.0E-04	-0.2	-2.12	-2.89	-3.32	-2.21	15.9	-6.03
Average	-	*8.67*	*109.9*	*3.2*	*30.4*	*102.6*	*60.30*	*0.17*	-	-	*-2.10*	*-2.91*	*-3.31*	*-2.21*	*15.8*	*-6.04*
±2δ	-	*±0.02*	*±2.4*	*±0.3*	*±0.7*	*±2.2*	-	-	-	-	*±0.03*	*±0.01*	*±0.04*	*±0.01*	±0.3	*±0.03*
ACMC_22	4.6	8.66	115.9	2.9	32.0	98.4	51.2	0.17	1.1E-03	0.4	-2.06	-2.89	-3.36	-2.19	21.2	-6.00
	7.8	8.67	115.9	2.9	30.8	97.8	51.2	0.16	-1.9E-03	-0.7	-2.07	-2.88	-3.36	-2.21	20.8	-6.00
	12.1	8.68	116.5	2.7	31.1	98.5	51.2	0.17	-1.6E-03	-0.6	-2.08	-2.87	-3.39	-2.21	21.0	-6.01

	17.9	8.69	115.0	2.9	32.7	98.1	51.2	0.17	3.1E-03	1.1	-2.10	-2.87	-3.36	-2.19	21.9	-5.97
	27.5	8.70	116.3	2.6	30.4	97.4	51.2	0.16	-4.1E-03	-1.5	-2.10	-2.85	-3.42	-2.22	21.3	-6.01
	44.7	8.71	115.3	2.7	32.3	103.7	51.2	0.17	7.2E-03	2.5	-2.13	-2.85	-3.40	-2.20	21.2	-6.00
Average	-	*8.69*	*115.8*	*2.8*	*31.6*	*99.0*	*51.2*	*0.17*	-	-	*-2.09*	*-2.87*	*-3.38*	*-2.20*	*21.2*	*-6.00*
±2δ	-	*±0.04*	*±1.1*	*±0.3*	*±1.8*	*±4.7*	-	*±0.01*	-	-	*±0.05*	*±0.03*	*±0.05*	*±0.02*	±0.7	*±0.03*
ACMC_31	2.0	8.89	126.9	2.5	36.0	103.0	54.0	0.17	1.0E-03	0.3	-2.32	-2.69	-3.49	-2.19	30.4	-5.79
	4.0	8.91	128.1	2.0	34.2	101.3	54.0	0.17	-4.1E-03	-1.4	-2.33	-2.66	-3.60	-2.22	29.0	-5.86
	6.1	8.92	124.9	2.1	36.2	104.9	54.0	0.17	-2.2E-04	-0.1	-2.36	-2.67	-3.57	-2.19	28.2	-5.85
	8.8	8.92	128.4	2.2	37.3	105.6	54.0	0.17	3.8E-04	0.1	-2.35	-2.66	-3.56	-2.18	29.2	-5.82
	11.9	8.93	128.4	2.3	40.1	102.1	54.0	0.18	9.1E-03	3.1	-2.38	-2.67	-3.53	-2.15	30.6	-5.78
	14.2	8.94	129.8	2.5	39.4	103.8	54.0	0.17	2.5E-03	0.9	-2.38	-2.65	-3.50	-2.16	29.3	-5.76
	18.6	8.94	125.3	2.5	40.4	106.6	54.0	0.17	9.6E-03	3.3	-2.40	-2.67	-3.49	-2.14	28.9	-5.77
	35.7	8.96	124.5	2.1	38.7	102.5	54.0	0.17	2.2E-03	0.8	-2.42	-2.65	-3.57	-2.17	28.9	-5.82
Average	-	*8.93*	*127.0*	*2.3*	*37.8*	*103.7*	*54*	*0.17*	-	-	*-2.37*	*-2.67*	*-3.54*	*-2.18*	*29.3*	*-5.81*
±2δ	-	*±0.04*	*±3.9*	*±0.4*	*±4.4*	*±3.7*	-	*±0.01*	-	-	*±0.07*	*±0.03*	*±0.08*	*±0.05*	±1.6	*±0.07*
ACMC_39	5.2	9.01	133.6	2.0	40.8	102.2	57.6	0.18	-3.4E-03	-1.2	-2.47	-2.59	-3.63	-2.17	37.2	-5.68
	8.2	9.02	133.7	1.8	39.9	102.2	57.6	0.18	-5.7E-03	-2.0	-2.47	-2.58	-3.68	-2.18	37.4	-5.70
	11.3	9.02	132.8	1.8	35.5	102.7	57.6	0.17	-1.3E-02	-4.5	-2.46	-2.57	-3.68	-2.24	37.7	-5.71
	14.9	9.02	132.9	1.7	35.2	102.7	57.6	0.17	-1.4E-02	-4.8	-2.46	-2.57	-3.71	-2.24	37.2	-5.73
	19.1	9.02	131.8	1.7	36.4	101.7	57.6	0.17	-1.2E-02	-4.0	-2.47	-2.58	-3.70	-2.22	37.7	-5.72
	39.1	9.02	133.2	1.8	37.6	102.0	57.6	0.17	-1.0E-02	-3.4	-2.47	-2.58	-3.68	-2.21	37.1	-5.72
Average	-	*9.02*	*133.0*	*1.8*	*37.6*	*102.3*	*57.6*	*0.17*	-	-	*-2.47*	*-2.58*	*-3.68*	*-2.21*	*37.4*	*-5.71*
±2δ	-	±0.01	±1.4	±0.2	±4.7	±0.8	-	±0.01	-	-	0.01	0.02	0.06	0.06	±0.5	±0.04
ACMC_53	1.7	9.11	141.7	1.6	47.9	101.5	61.3	0.18	-2.5E-03	-0.8	-2.60	-2.53	-3.75	-2.12	51.2	-5.44
	3.9	9.14	143.3	1.6	49.4	103.7	61.3	0.19	1.1E-03	0.4	-2.64	-2.51	-3.76	-2.11	51.2	-5.43
	5.7	9.14	143.8	1.6	49.9	104.6	61.3	0.19	2.5E-03	0.8	-2.64	-2.51	-3.76	-2.11	51.4	-5.42
	10.4	9.15	144.3	1.5	49.5	103.7	61.3	0.19	1.0E-04	0.0	-2.65	-2.50	-3.80	-2.12	51.7	-5.43
	13.5	9.15	143.9	1.5	49.1	101.8	61.3	0.18	-2.2E-03	-0.7	-2.65	-2.50	-3.80	-2.12	50.9	-5.45
	18.6	9.16	143.3	1.5	48.5	103.5	61.3	0.18	-1.1E-03	-0.4	-2.66	-2.49	-3.80	-2.13	51.6	-5.43
Average	-	*9.14*	*143.4*	*1.6*	*49.1*	*103.1*	*61.30*	*0.19*	-	-	*-2.64*	*-2.51*	*-3.78*	*-2.12*	*51.3*	*-5.43*
±2δ	-	±0.03	±1.8	±0.1	±1.5	±2.4	-	±0.01	-	-	±0.04	±0.03	±0.05	±0.01	±0.6	±0.02
ACMC_80	1.8	9.23	159.4	1.0	51.5	99.8	56.5	0.18	-1.1E-02	-3.7	-2.72	-2.41	-4.03	-2.14	78.3	-4.96
	3.9	9.25	162.0	0.9	52.2	100.5	56.5	0.18	-1.2E-02	-4.1	-2.74	-2.39	-4.08	-2.14	78.5	-4.95
	5.7	9.26	160.6	0.8	52.1	100.2	56.5	0.18	-1.1E-02	-3.8	-2.76	-2.39	-4.13	-2.14	78.4	-4.96
	7.8	9.27	161.4	0.8	51.8	100.1	56.5	0.18	-1.3E-02	-4.3	-2.77	-2.38	-4.14	-2.15	78.8	-4.95
Average	-	*9.25*	*160.9*	*0.9*	*51.9*	*100.2*	*56.50*	*0.18*	-	-	*-2.75*	*-2.39*	*-4.10*	*-2.14*	*78.5*	*-4.96*
±2δ	-	±0.03	±2.3	±0.2	±0.6	±0.6	-	-	-	-	±0.04	±0.03	±0.10	±0.01	±0.4	±0.01
AMC	1.9	9.39	181.4	0	61.6	100.1	57.0	0.19	-1.5E-02	-5.0	-2.92	-2.29	-	-2.12	100	-4.41
	3.8	9.39	175.7	0	59.8	102.4	57.0	0.19	-1.1E-02	-3.6	-2.93	-2.30	-	-2.12	100	-4.42
Average	-	*9.39*	*178.6*	-	*60.7*	*101.3*	*57.00*	*0.19*	-	-	*-2.93*	*-2.30*	-	*-2.12*	*100*	*-4.42*

$\pm 2\delta$	-	-	±8.1	-	±2.6	±3.3	-	-	-	-	±0.01	±0.01	-	-	-	±0.01

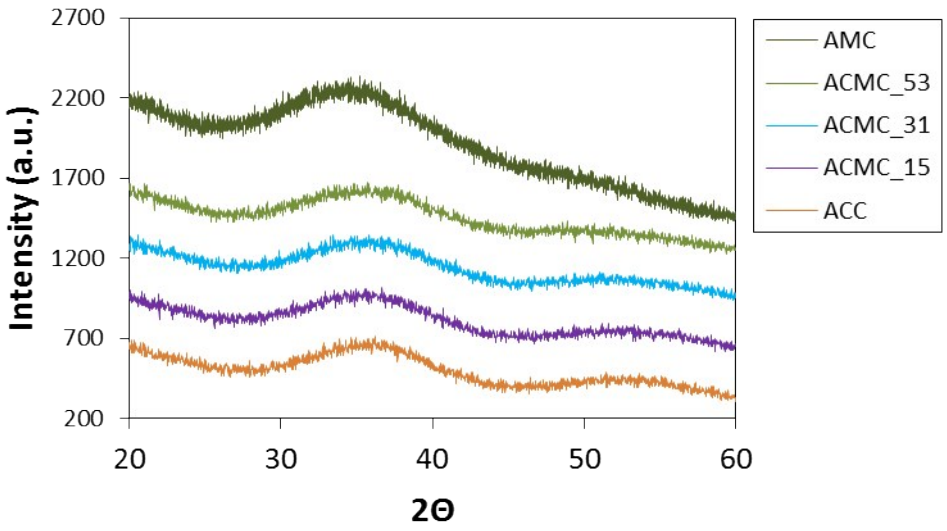

Figure S1: X-ray diffraction patterns of representative synthetic ACMC samples (see Table 1).

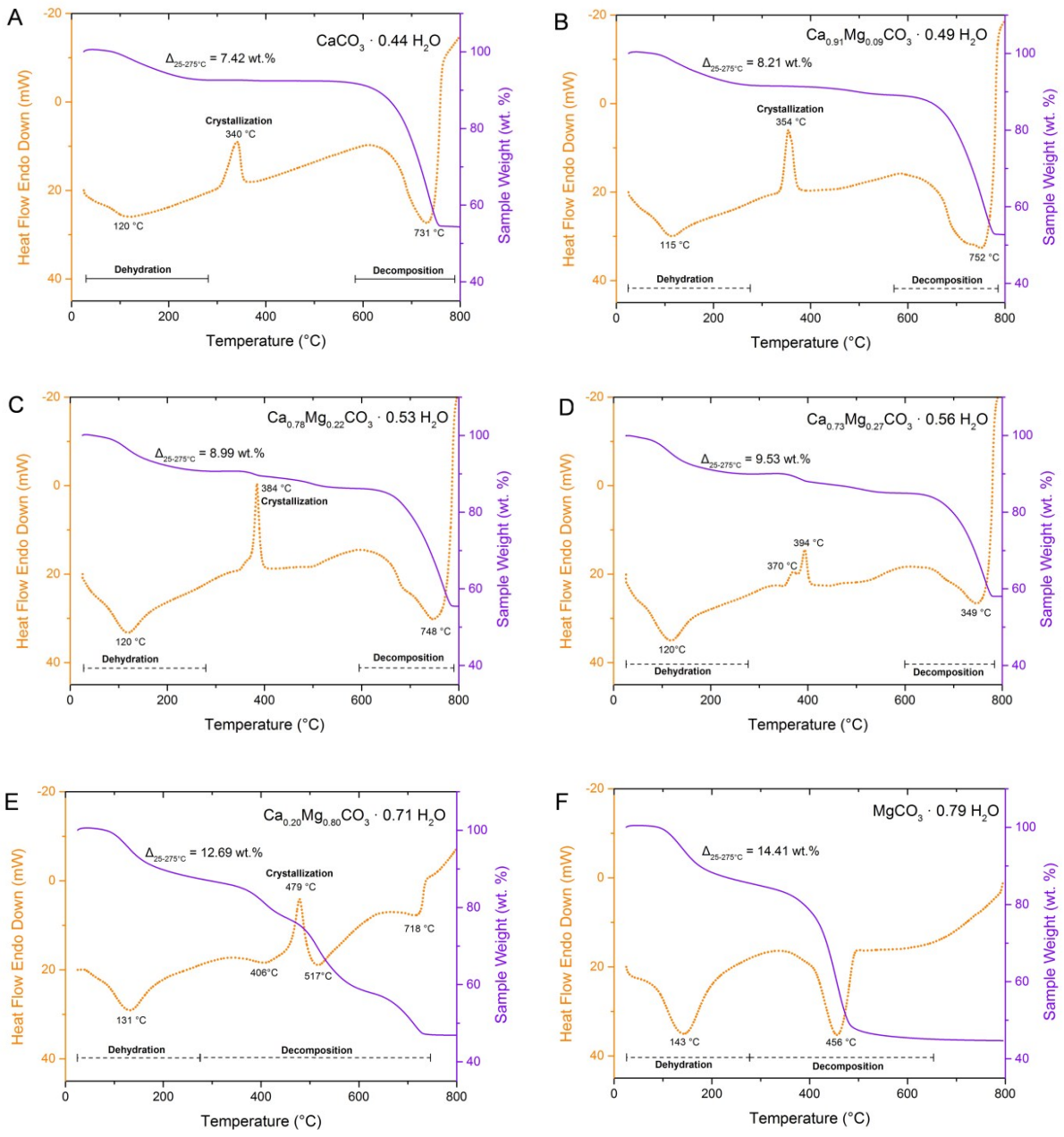

Figure S2: Thermogravimetric analysis (TGA – organge solid lines) and differential scanning calorimetry (DSC – violet dashed lines) curves of ACC (A), ACMC_9 (B), ACMC_22 (C), ACMC_53(D), ACMC_80 (E) and AMC (H) synthesized in the context of the present study (see Table 1).

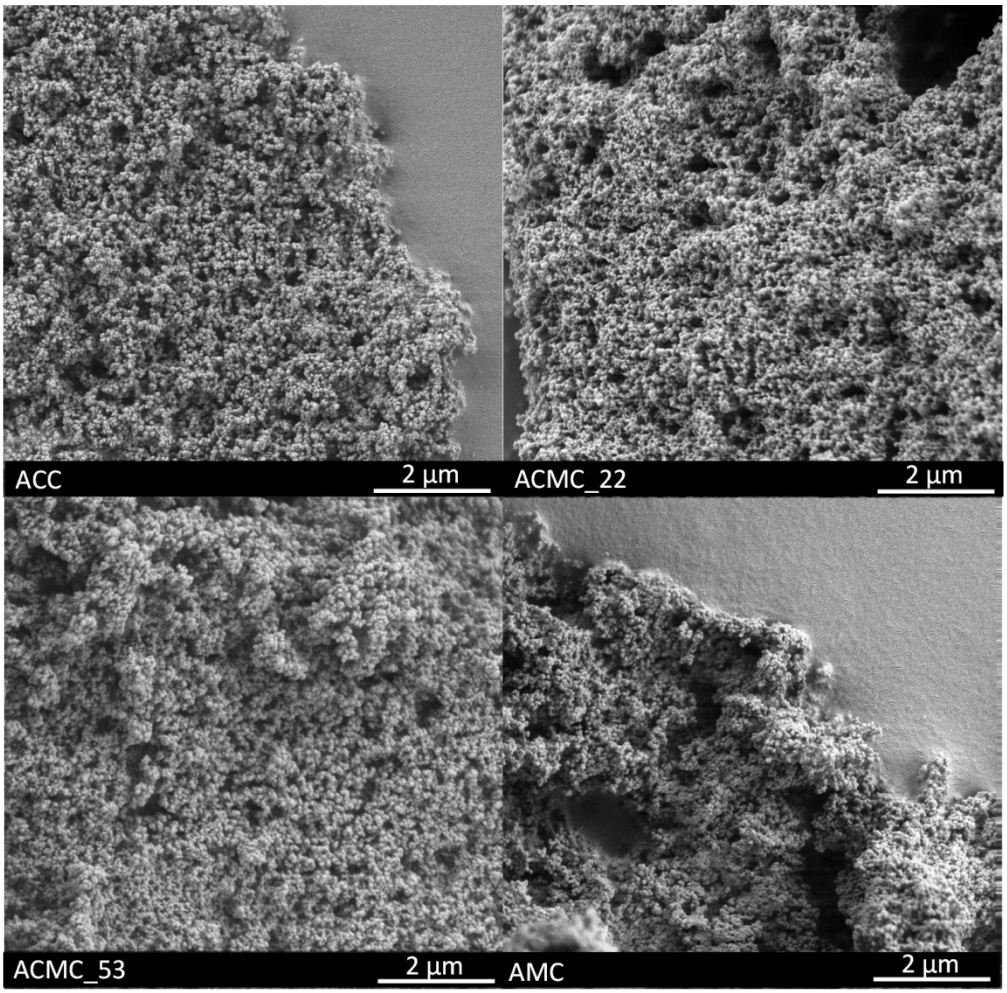

Figure S3: Scanning Electron Microscopy (SEM) images of representative ACMC samples (see Table 1).

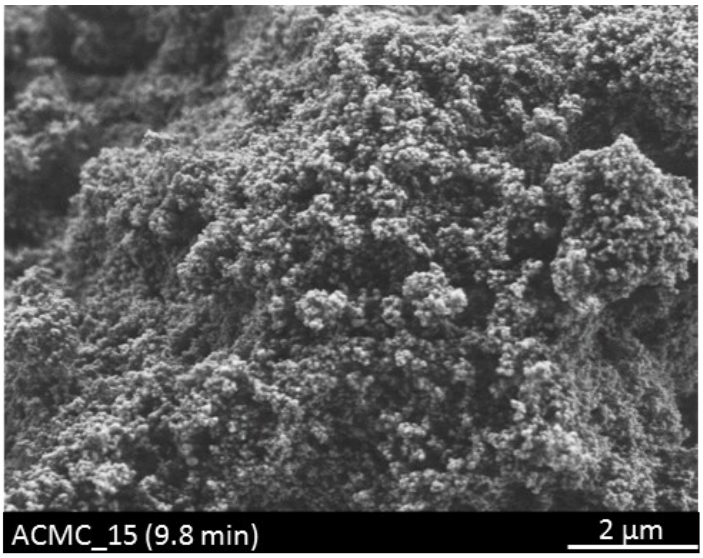

Figure S4: Scanning Electron Microscopy (SEM) image of ACMC collected after 9.8 min of reaction time in the experiment conducted with 15 mol% Mg (ACMC_15).