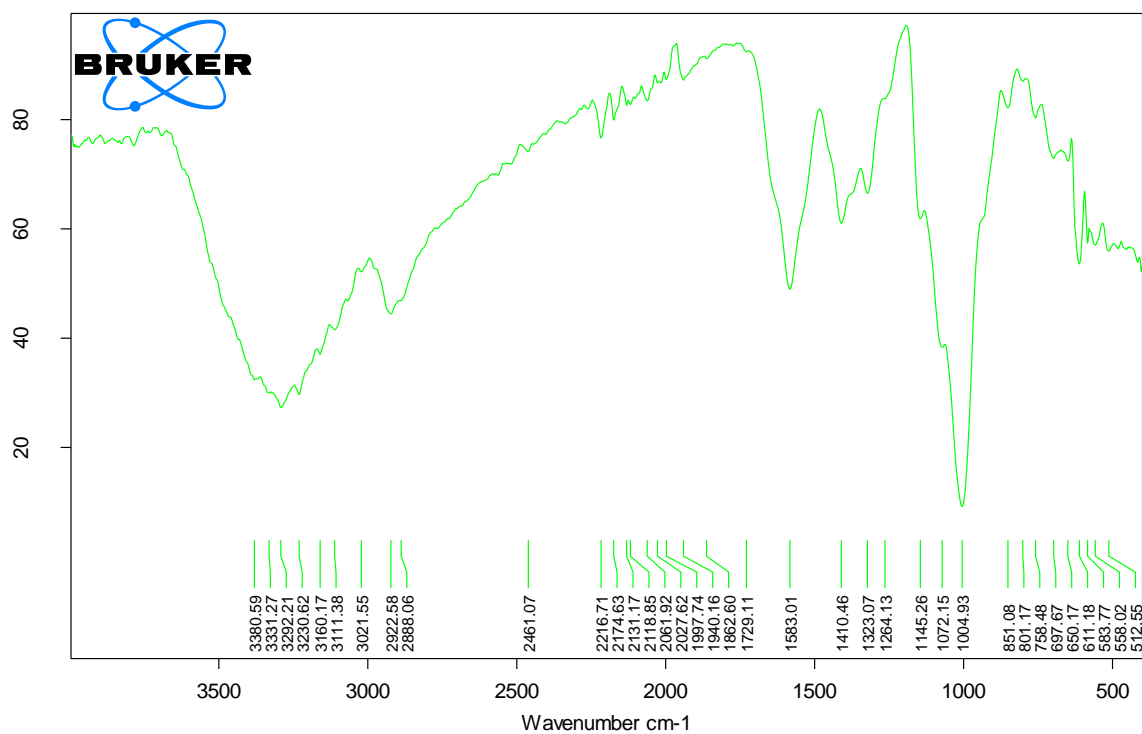


C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\01.07 1-1-0,01 norm.SPA.0

**01.07. 1-1-0,01

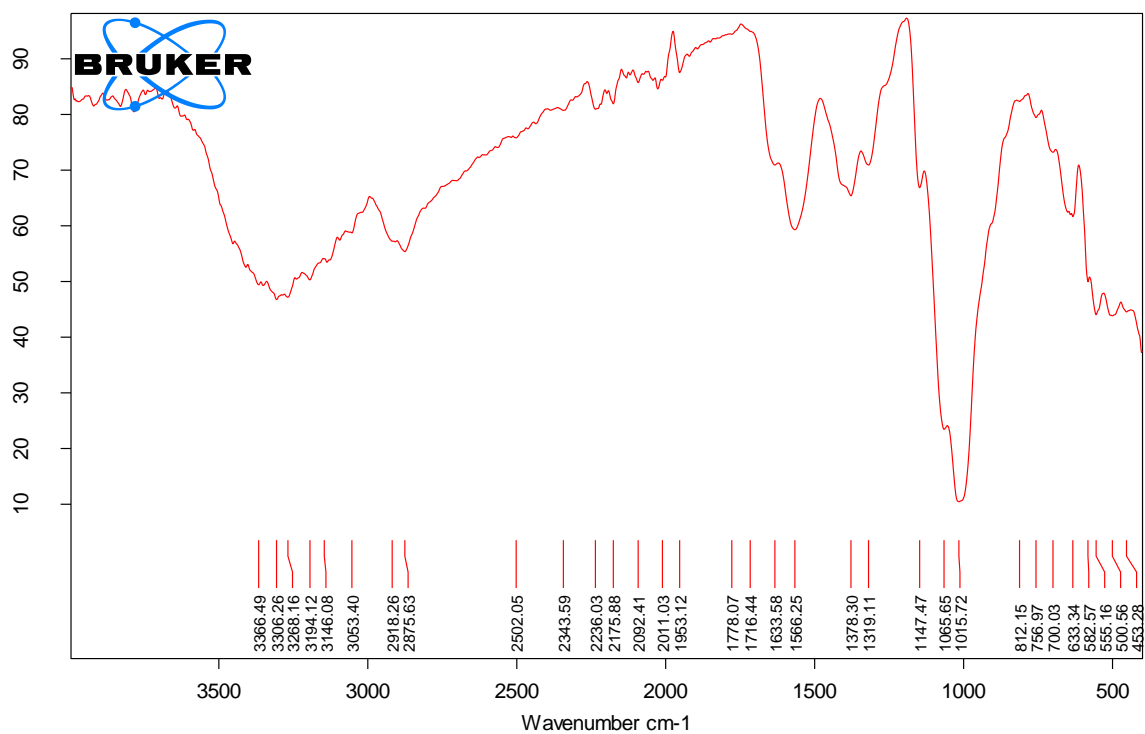
01.09.2020

Figure S1. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.01 vanillin (Van).



C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\14.07. I 0,25-1,75-0,01 norm.SPA.0 **14.07. I 0, 01.09.2020

Figure S2. FTIR spectrum of the sample prepared with the ratio 0.25 carboxymethyl starch (CMS): 1.75 chitosan (Ch): 0.01 vanillin (Van).

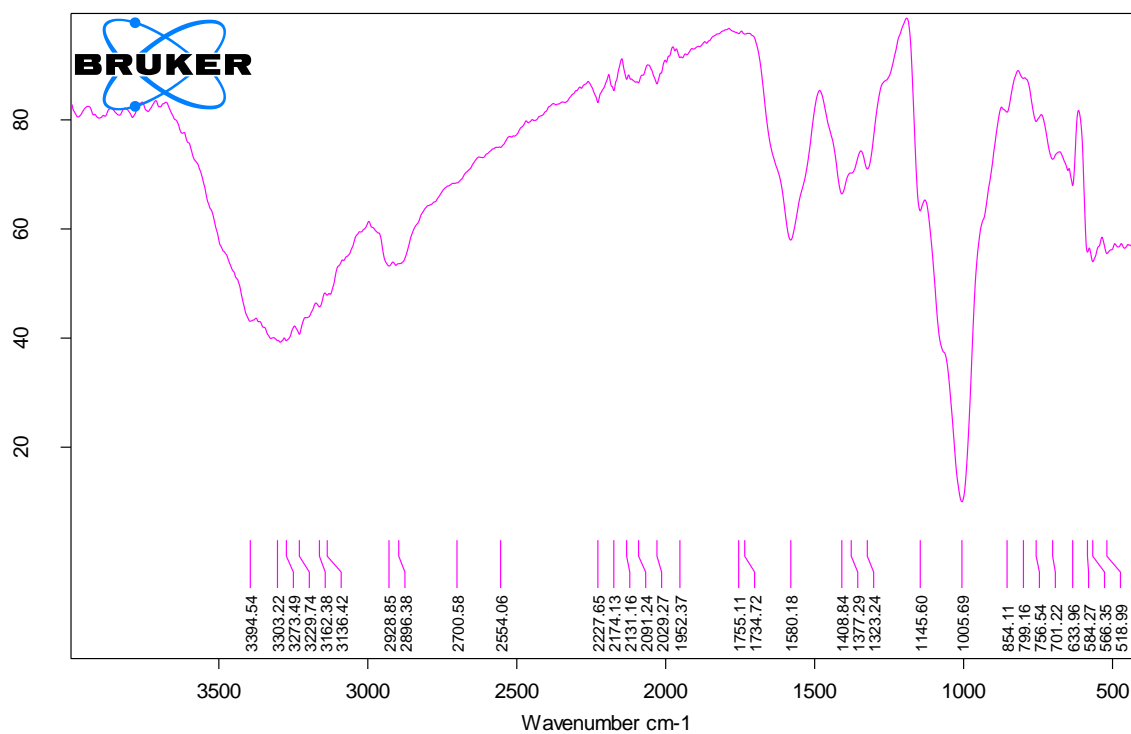


C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\01.07 1-1-0,02 norm.SPA.0

**01.07. 1-1-0,02

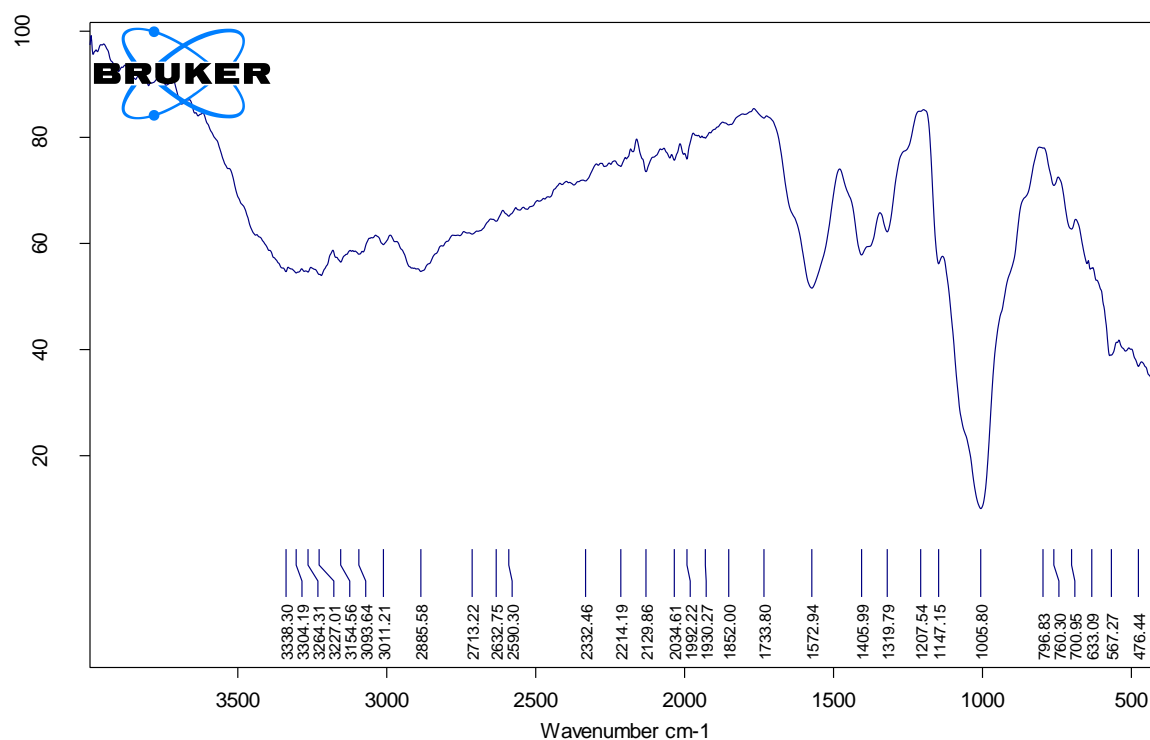
01.09.2020

Figure S3. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.02 vanillin (Van).



C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\14.07 0,5-1,5-0,02 norm.SPA.0 **14.07. I 0,5-1,5 01.09.2020

Figure S4. FTIR spectrum of the sample prepared with the ratio 0.5 carboxymethyl starch (CMS): 1.5 chitosan (Ch): 0.02 vanillin (Van).

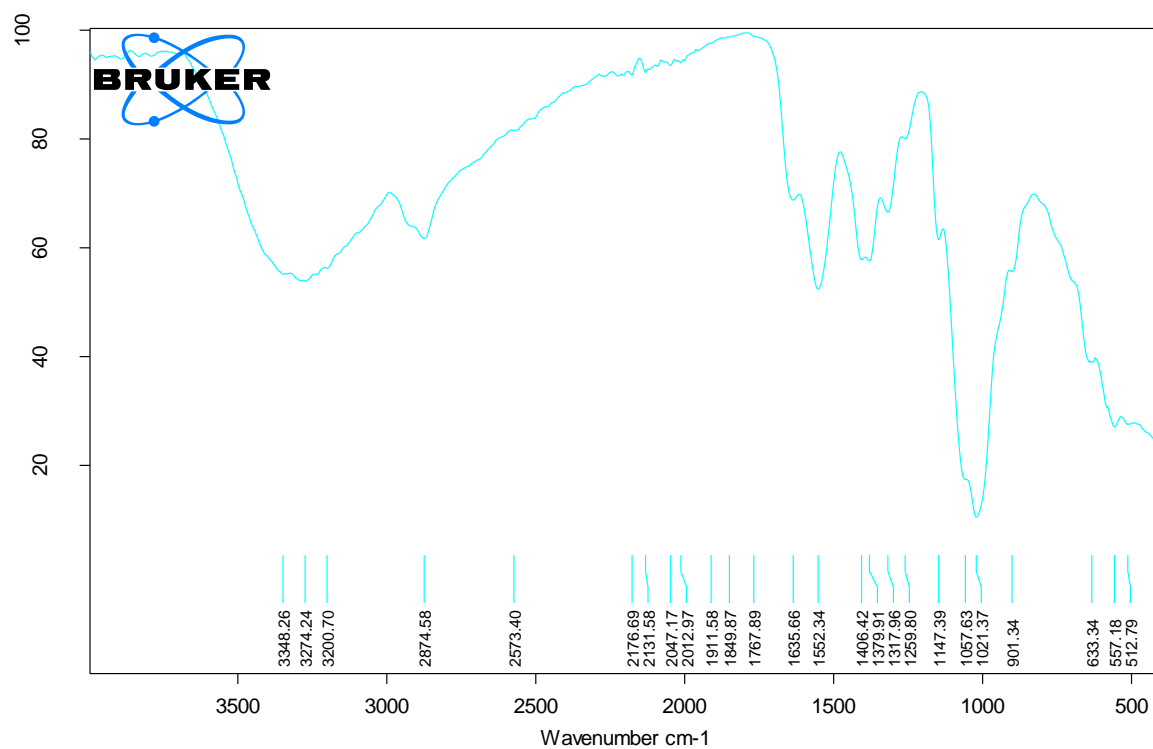


E:\2019\Dokumenty\Doktorat 2018\Obliczenia\IR syntezy SAP\Natural\CMS-g-Ch\publikacja\02.04-0,04.SPA

**02.04-0.04

14.05.2020

Figure S5. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.04 vanillin (Van).



C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\14.07. III 1,5-0,05-0,06 norm.SPA.0 **14.07. III 1 01.09.2020

Figure S6. FTIR spectrum of the sample prepared with the ratio 1.5 carboxymethyl starch (CMS): 0.5 chitosan (Ch): 0.06 vanillin (Van).

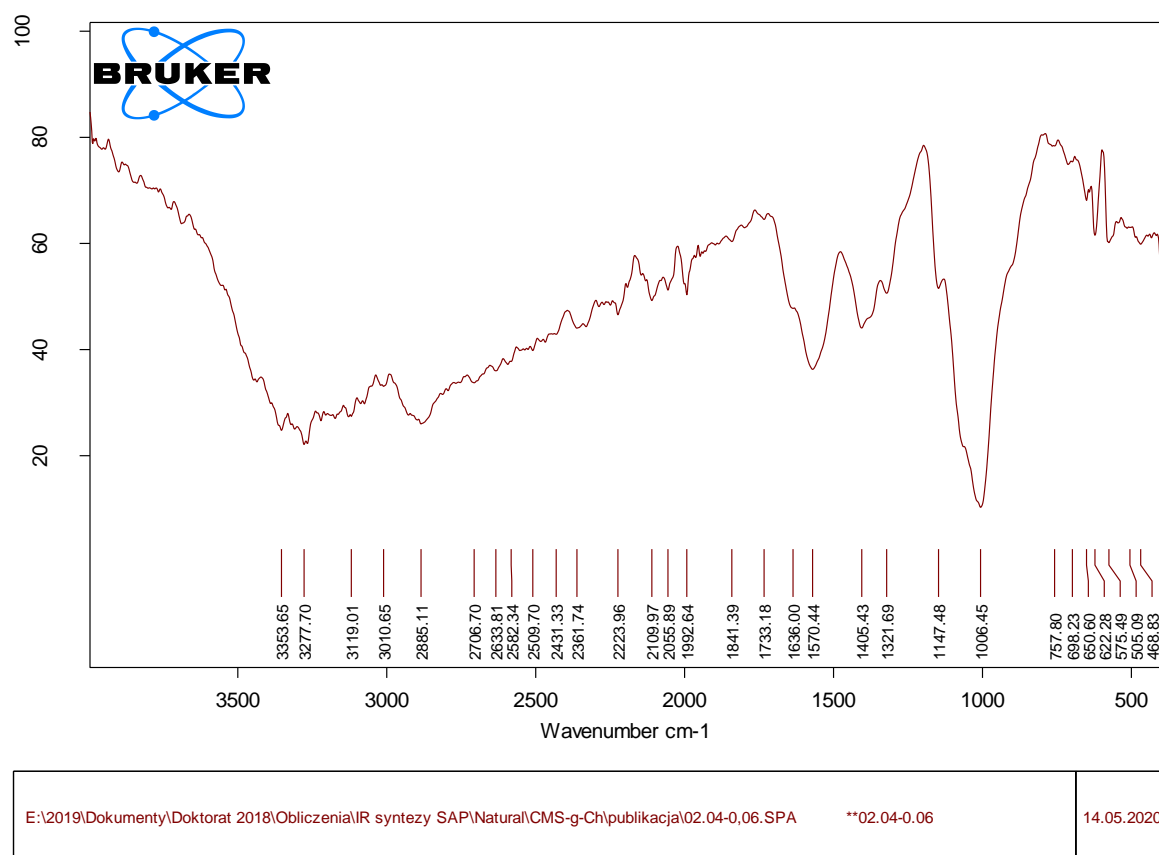
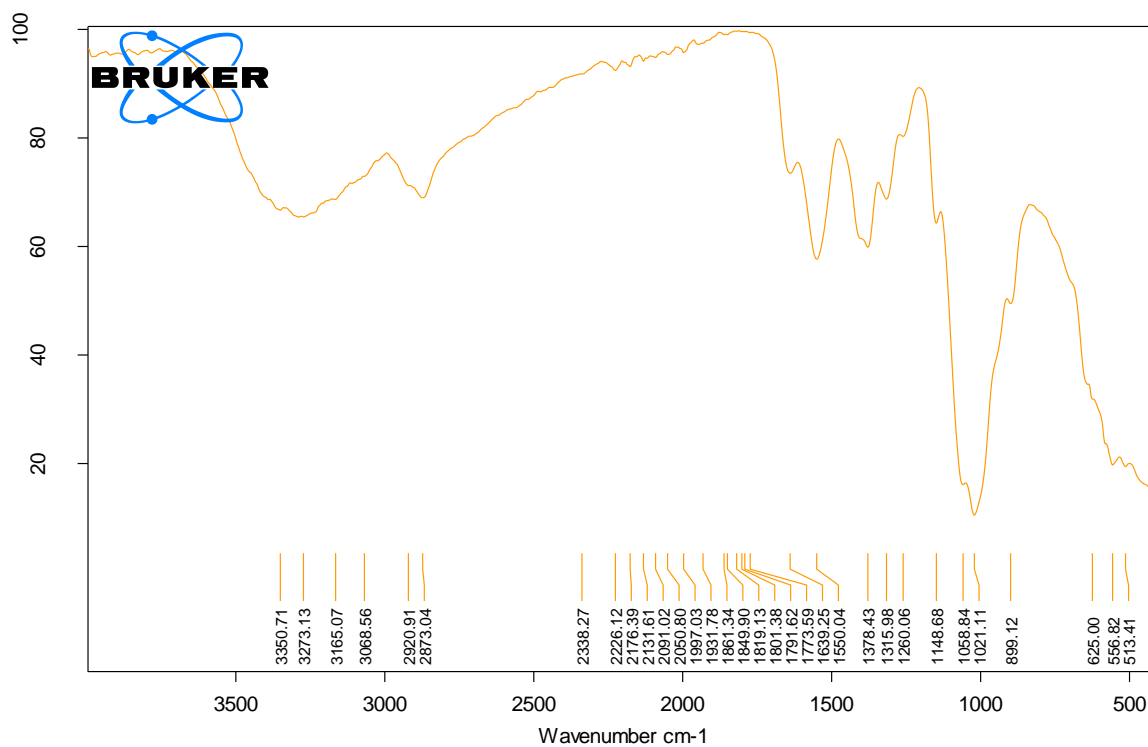


Figure S7. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.06 vanillin (Van).



C:\Users\Lenovo\Desktop\Obliczenia\IR syntezy SAP\SAP Natural\CMS-g-Ch\IR pick picking\14.07. IV 1,75-0,25-0,07 norm.SPA.0

**14.07. IV 01.09.2020

Figure S8. FTIR spectrum of the sample prepared with the ratio 1.75 carboxymethyl starch (CMS): 0.25 chitosan (Ch): 0.07 vanillin (Van).

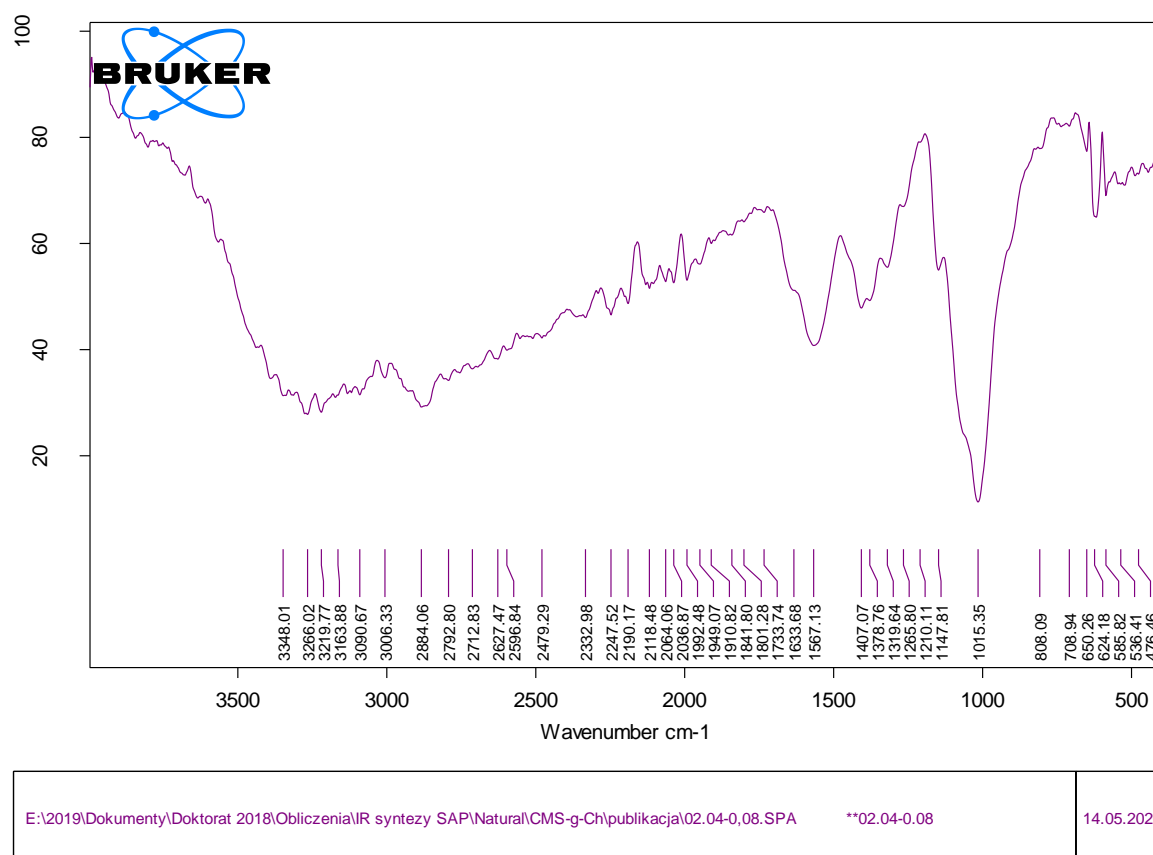


Figure S9. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.08 vanillin (Van).

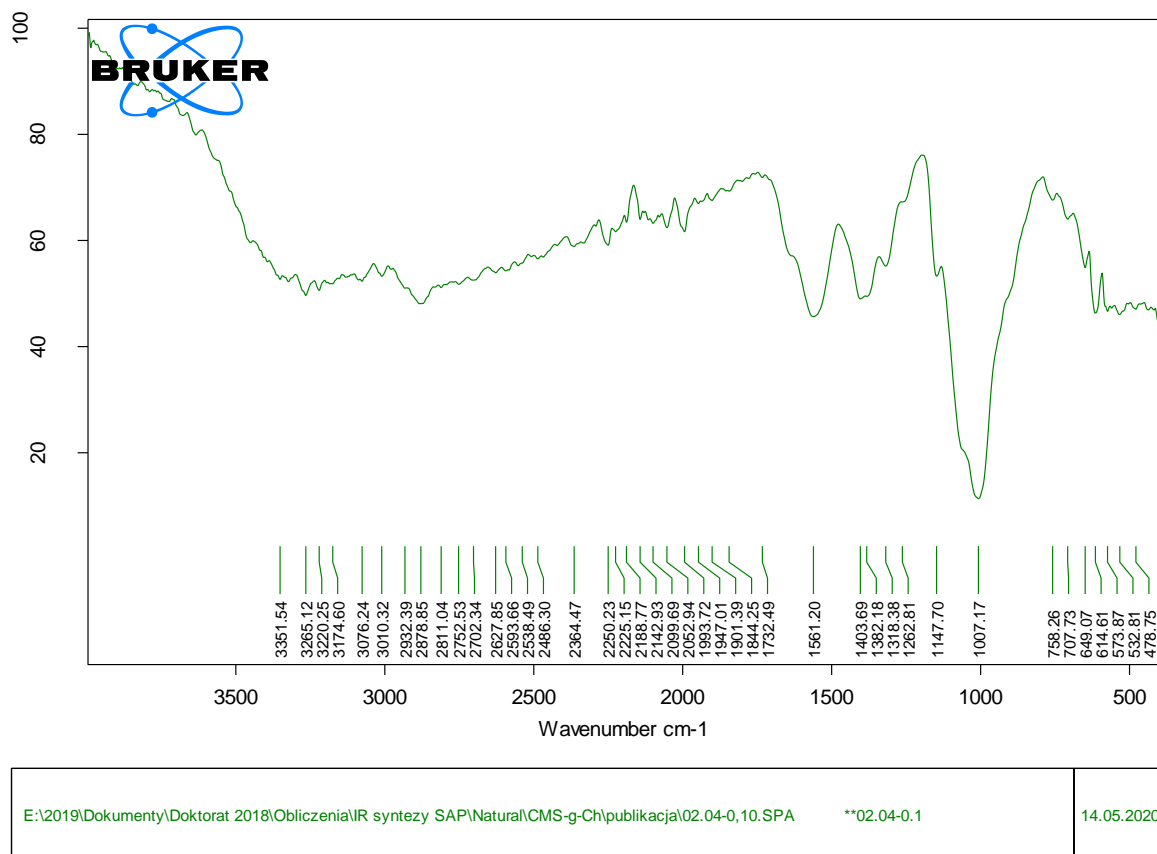
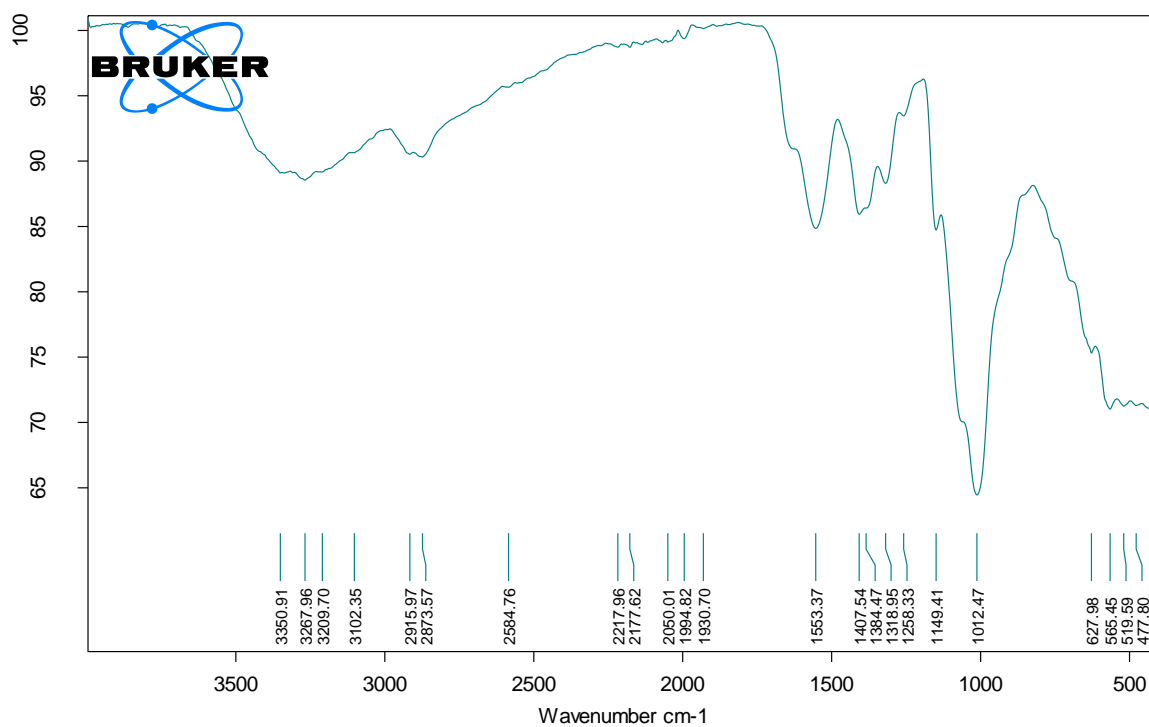


Figure S10. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch): 0.10 vanillin (Van).

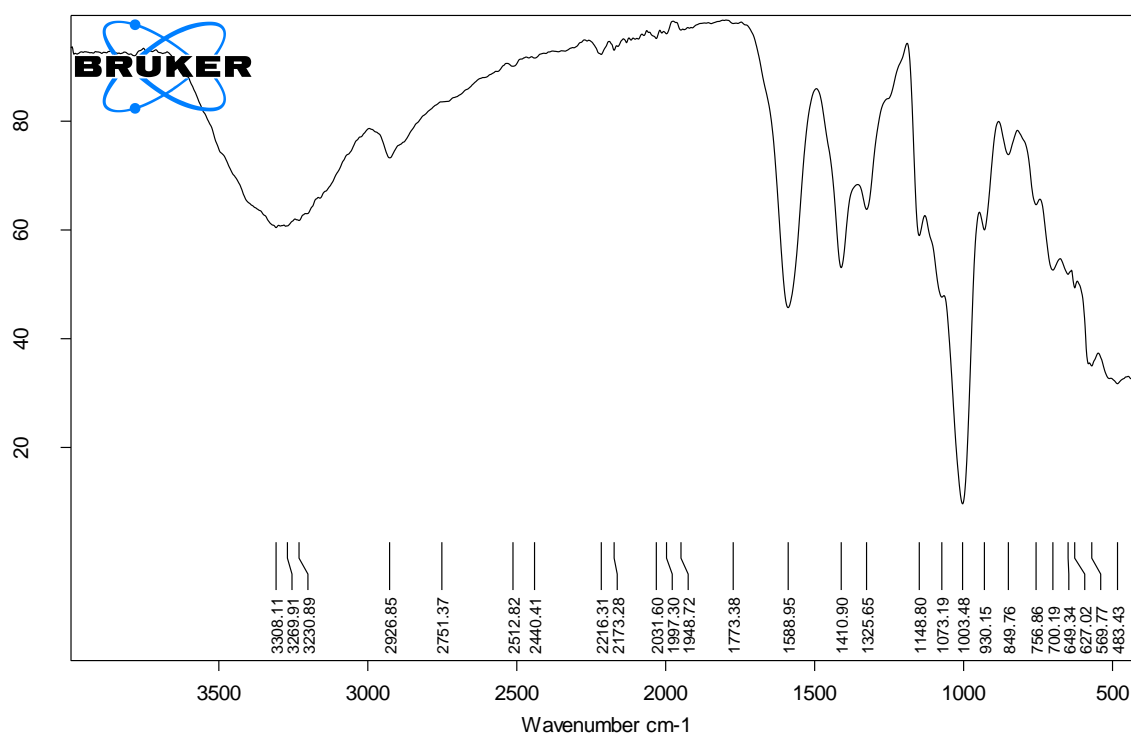


E:\2019\Dokumenty\Doktorat 2018\Obliczenia\IR syntezy SAP\Natural\CMS-g-Ch\publikacja\bez Van.SPA

*CMS g-Ch bez Van

05.05.2020

Figure S11. FTIR spectrum of the sample prepared with the ratio 1.0 carboxymethyl starch (CMS): 1.0 chitosan (Ch).

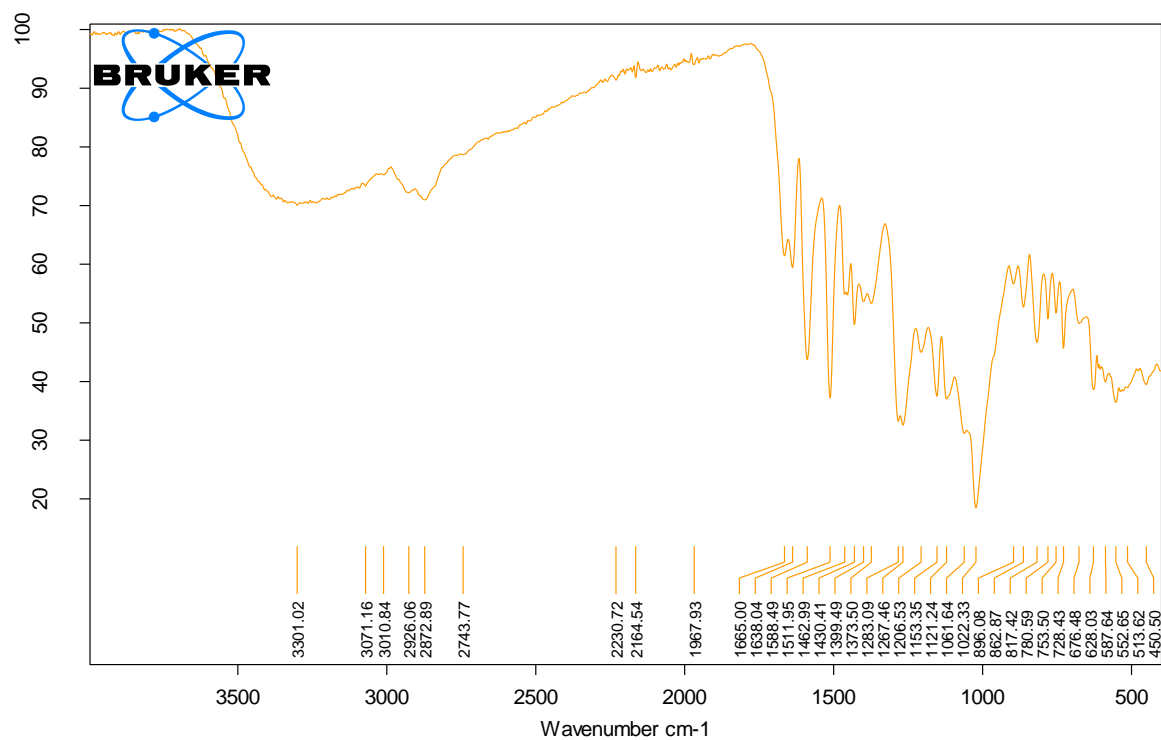


E:\2019\Dokumenty\Doktorat 2018\Obliczenia\IR syntezy SAP\Natural\CMS-g-Ch\publikacja\03.07 CMS.SPA

**03.07. CMS

01.09.2020

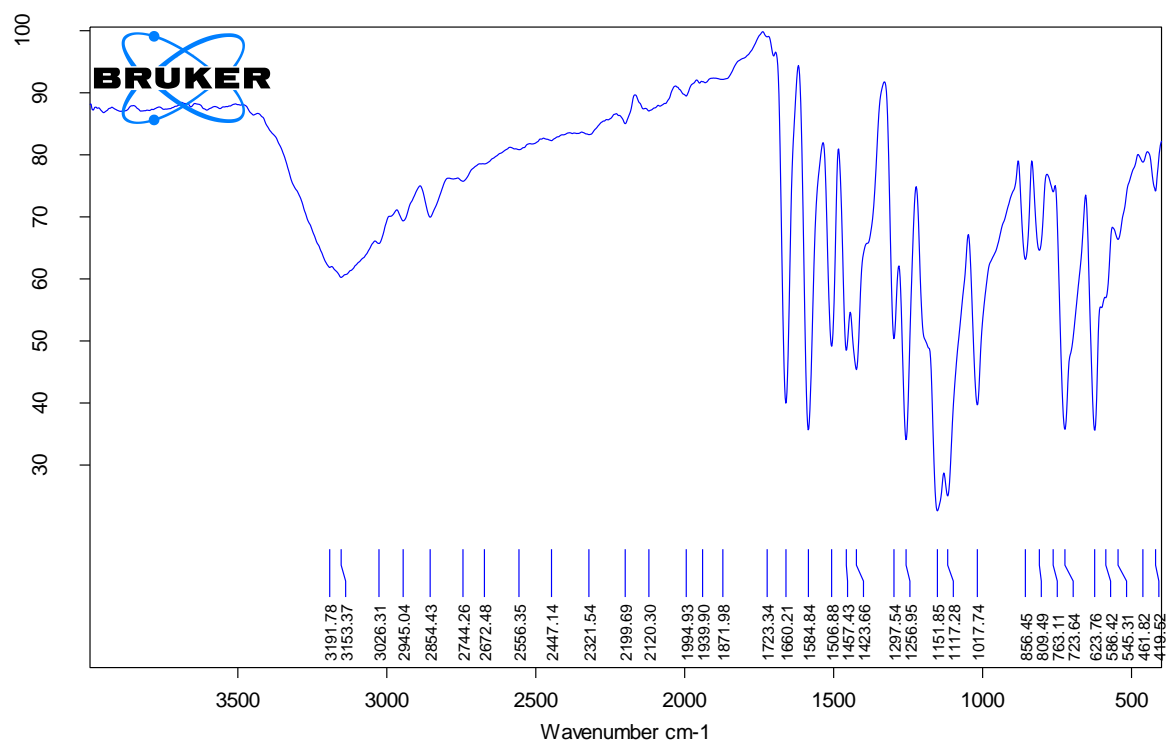
Figure S12. FTIR spectrum of the carboxymethyl starch (CMS).



E:\2019\Dokumenty\Doktorat 2018\Obliczenia\IR syntezy SAP\Natural\CMS-g-Ch\publikacja\Ch-V50.SPA Ch-V50

27.01.2020

Figure S13. FTIR spectrum of the chitosan (Ch).



E:\2019\Dokumenty\Doktorat 2018\Obliczenia\IR syntezy SAP\Natural\CMS-g-Ch\publikacja\Van.SPA

**Van

28.04.2020

Figure S14. FTIR spectrum of the vanillin (Van).

Sample: 01_06_bez
Size: 2.5258 mg

SDT

File: E:\...732020_123 PM_01_06_bez.UA
Operator: KW
Run Date: 03-Jul-2020 15:09

Comment: N2, 10C/min do 1000C

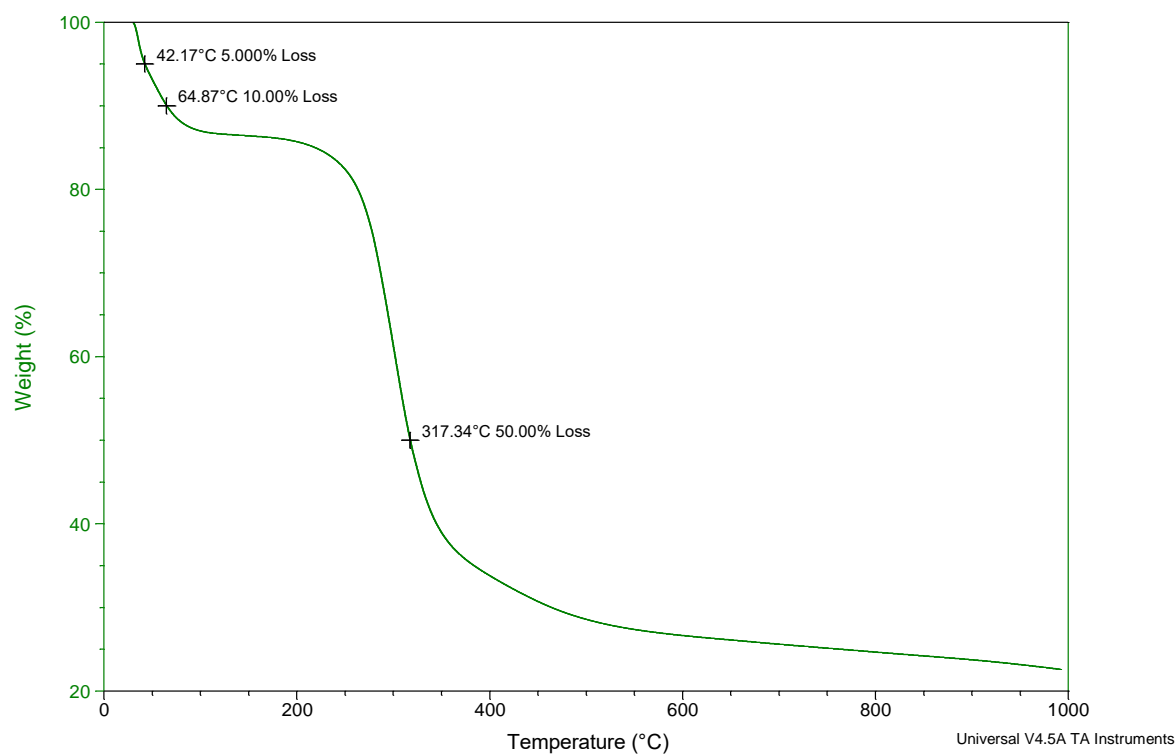


Figure S15. . TGA of 1.0 carboxymethyl starch : 1.0 chitosan.

Sample: 01_06_bez
Size: 2.5258 mg

SDT

File: E:\...732020_123 PM_01_06_bez.UA
Operator: KW
Run Date: 03-Jul-2020 15:09

Comment: N2, 10C/min do 1000C

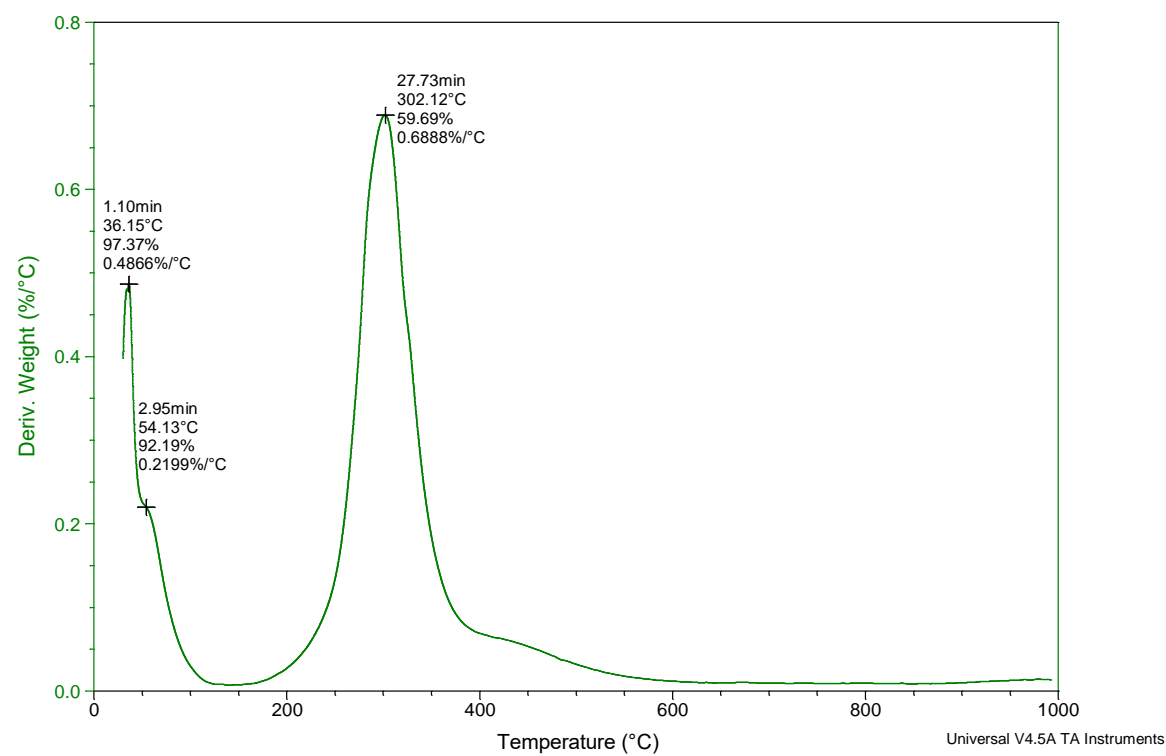


Figure S16. DTA of 1.0 carboxymethyl starch : 1.0 chitosan.

Sample: 02,04_0,04
Size: 8.8950 mg

SDT

File: E:\...712020_743 AM_02,04_0,04.UA
Operator: KW
Run Date: 01-Jul-2020 10:21

Comment: N2, 10C/min do 1000C

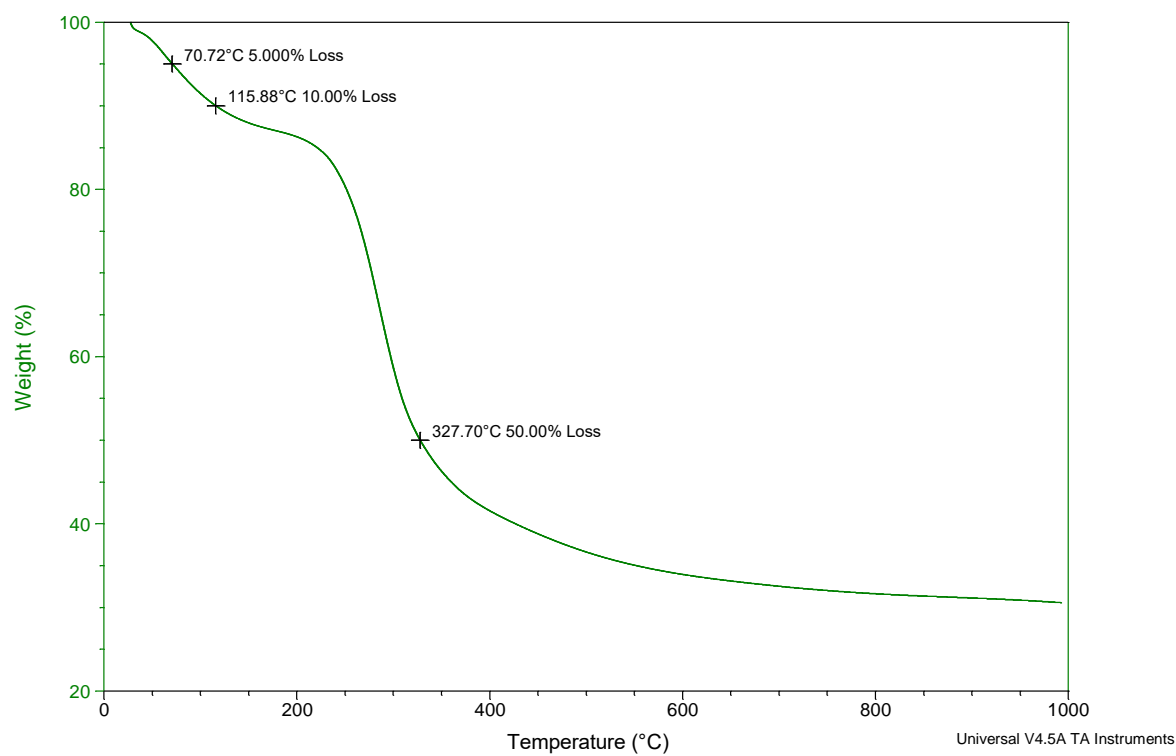


Figure S17. TGA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.04 vanillin.

Sample: 02,04_0,04
Size: 8.8950 mg

SDT

File: E:\...712020_743 AM_02,04_0,04.UA
Operator: KW
Run Date: 01-Jul-2020 10:21

Comment: N2, 10C/min do 1000C

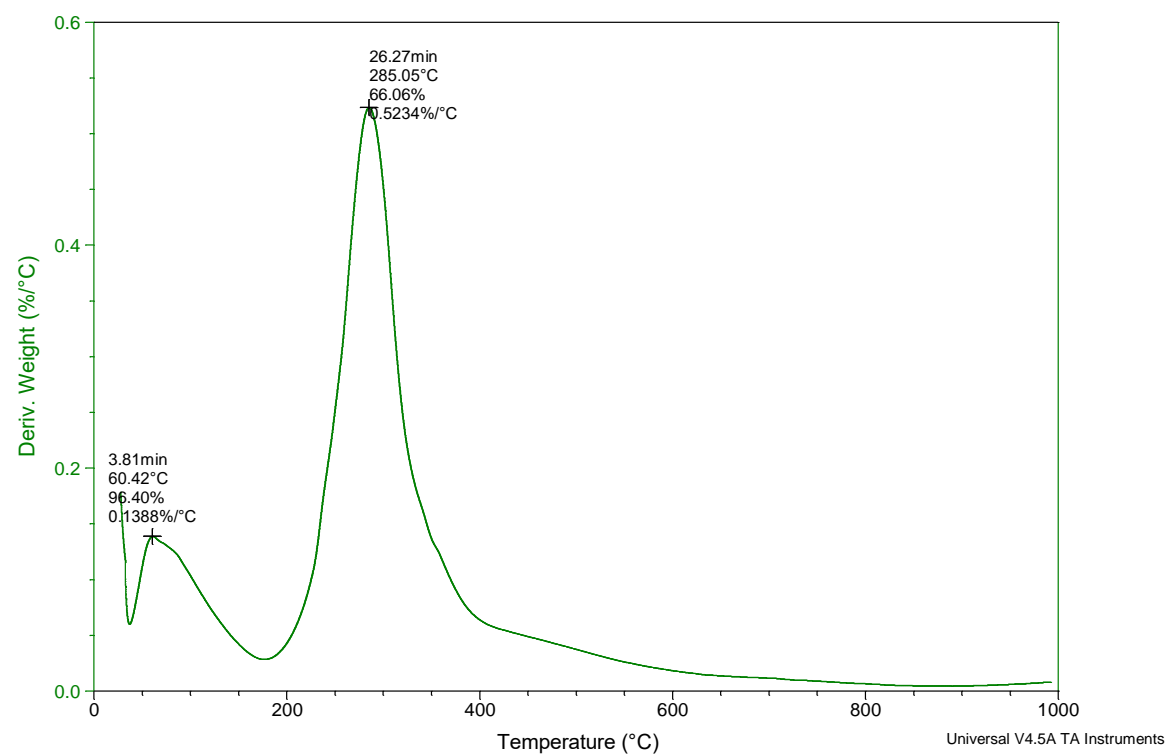


Figure S18. DTA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.04 vanillin.

Sample: 02,04_0,06
Size: 5.8537 mg

SDT

File: E:\...732020_743 AM_02,04_0,06.UA
Operator: KW
Run Date: 03-Jul-2020 10:19

Comment: N2, 10C/min do 1000C

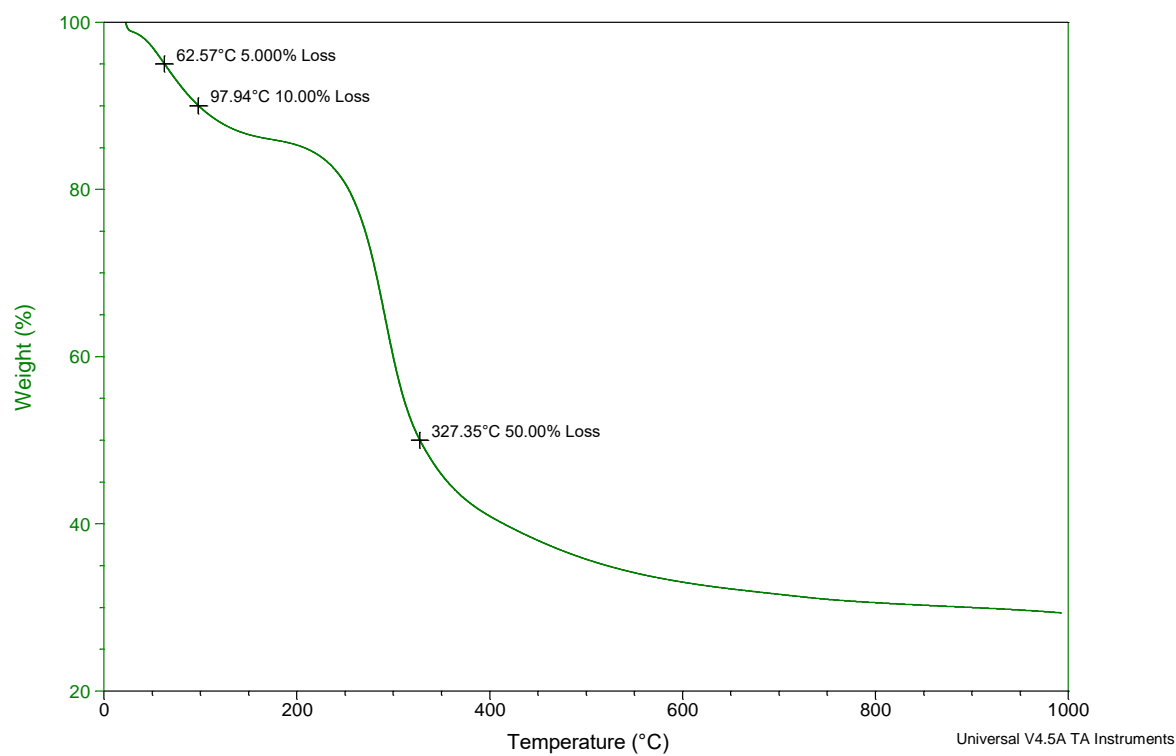


Figure S19. TGA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.06 vanillin.

Sample: 02,04_0,06
Size: 5.8537 mg

SDT

File: E:\...732020_743 AM_02,04_0,06.UA
Operator: KW
Run Date: 03-Jul-2020 10:19

Comment: N2, 10C/min do 1000C

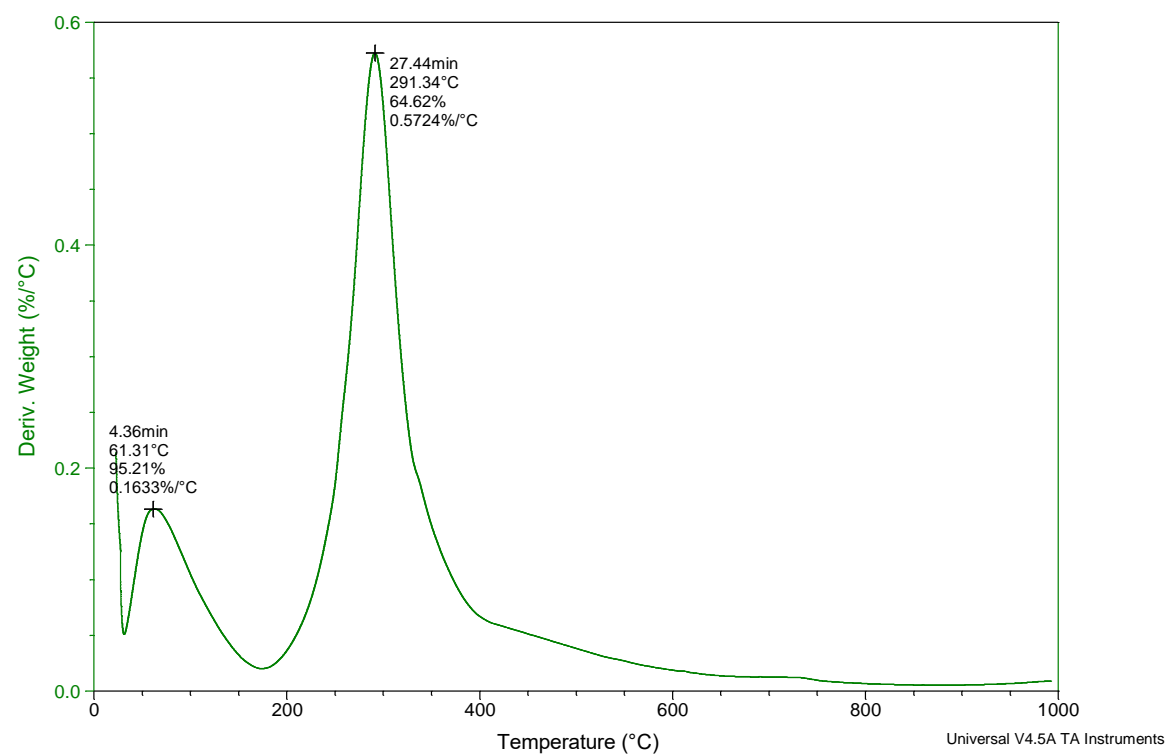


Figure S20. DTA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.06 vanillin.

Sample: 02,04_0,08
Size: 10.5446 mg

SDT

File: E:\...762020_1028 AM_02,04_0,08.UA
Operator: KW
Run Date: 06-Jul-2020 13:02

Comment: N2, 10C/min do 1000C

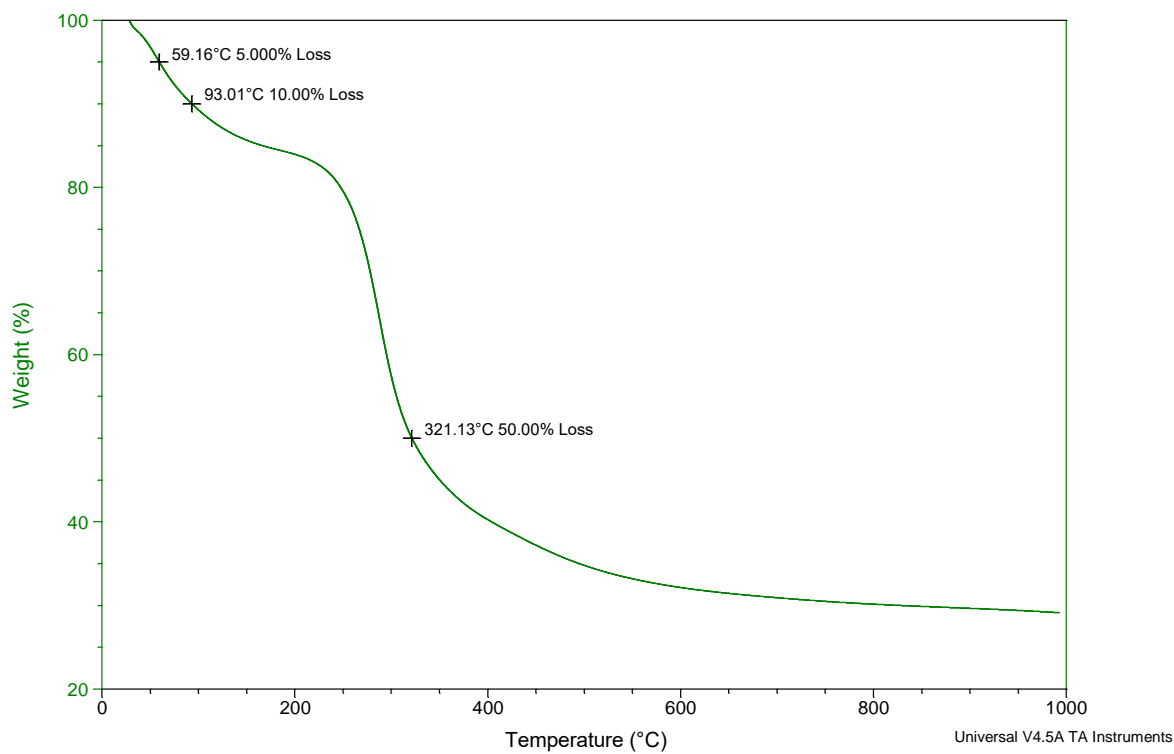


Figure S21. TGA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.08 vanillin.

Sample: 02,04_0,08
Size: 10.5446 mg

SDT

File: E:\...762020_1028 AM_02,04_0,08.UA
Operator: KW
Run Date: 06-Jul-2020 13:02

Comment: N2, 10C/min do 1000C

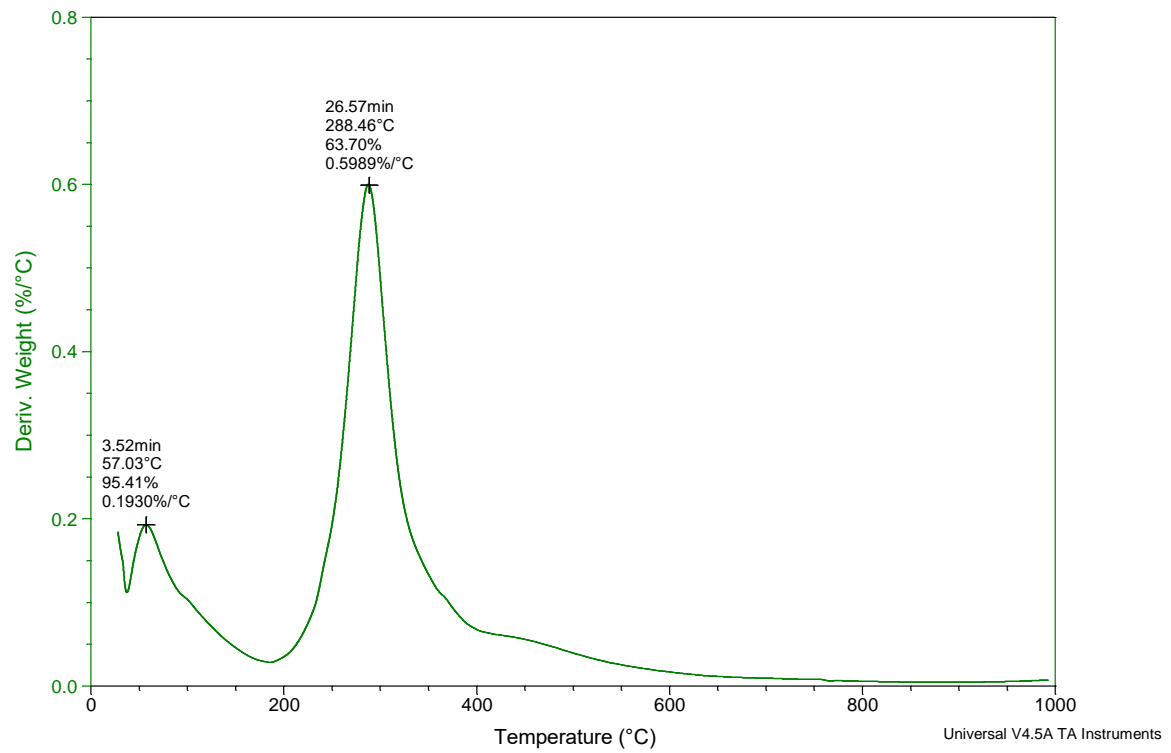


Figure S22. DTA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.08 vanillin.

Sample: 02,04_0,1
Size: 7.5769 mg

SDT

File: E:\...772020_1224 PM_02,04_0,1.UA
Operator: KW
Run Date: 07-Jul-2020 14:15

Comment: N2, 10C/min do 1000C

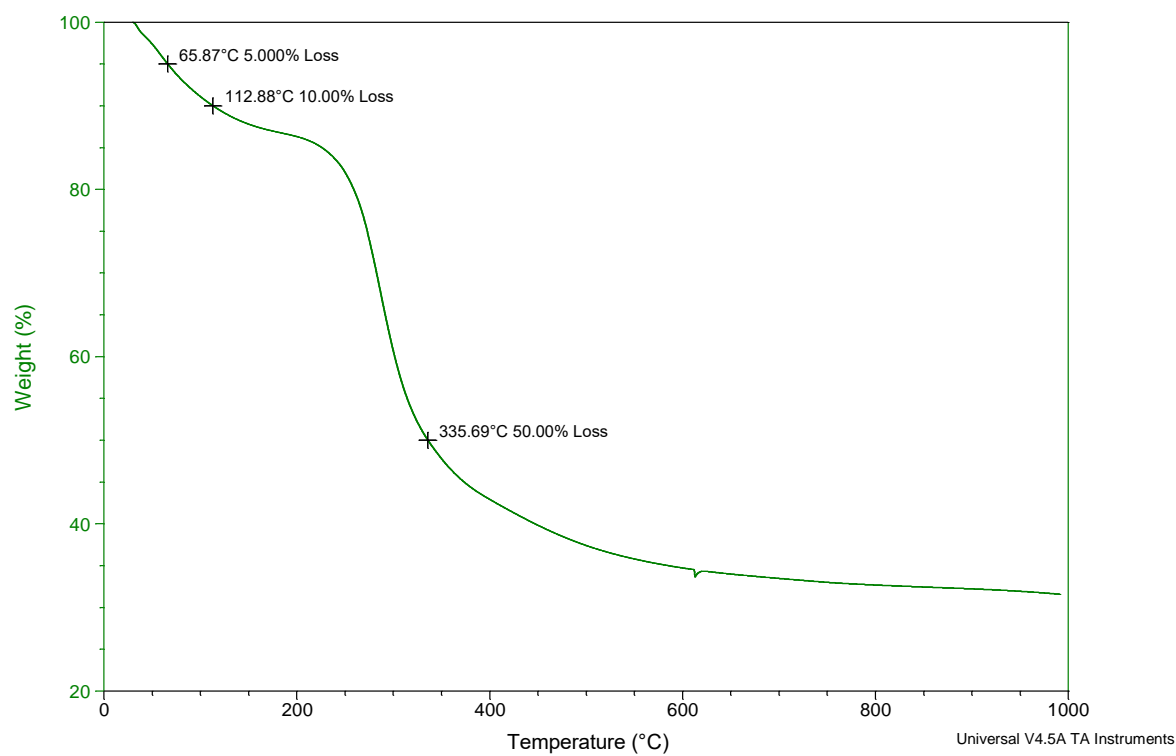


Figure S23. TGA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.10 vanillin.

Sample: 02,04_0,1
Size: 7.5769 mg

SDT

File: E:\...772020_1224 PM_02,04_0,1.UA
Operator: KW
Run Date: 07-Jul-2020 14:15

Comment: N2, 10C/min do 1000C

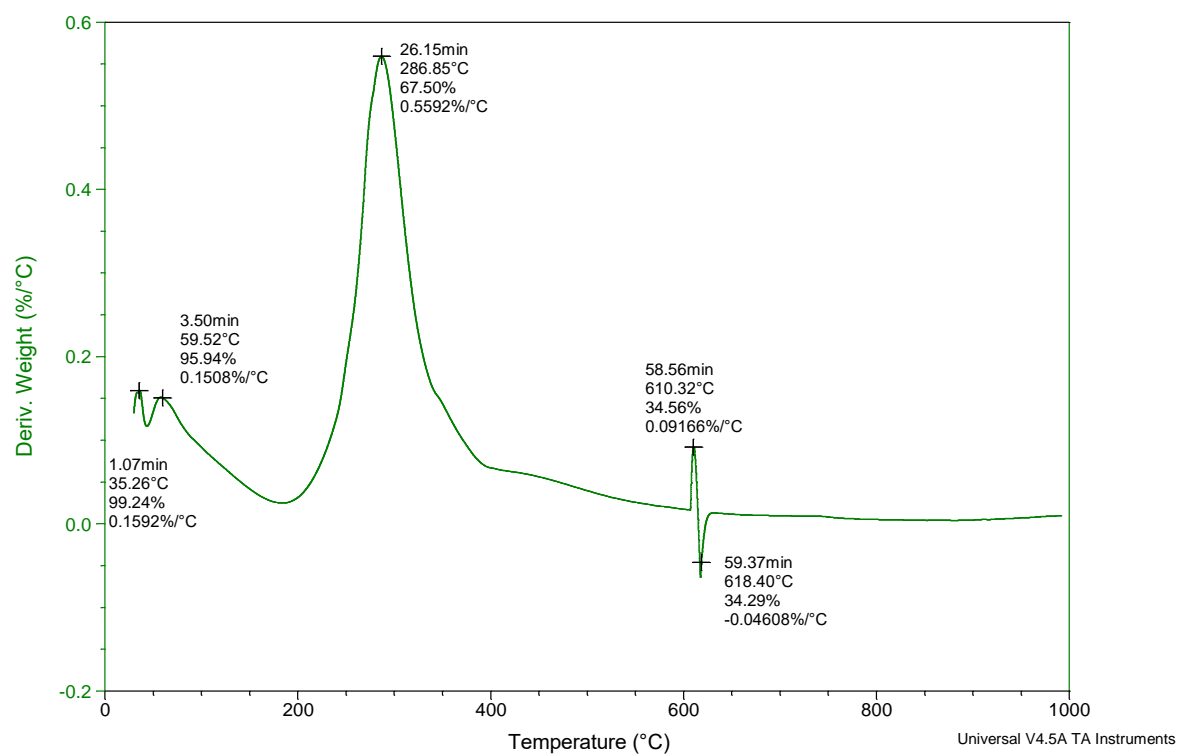


Figure S24. DTA of 1.0 carboxymethyl starch : 1.0 chitosan : 0.10 vanillin.

Sample: 15,04_CMS_powt1
Size: 6.1679 mg

SDT

File: E:\...722020_1213 PM_15,04_CMS_powt1.UA
Operator: KW
Run Date: 02-Jul-2020 14:48

Comment: N2, 10C/min do 1000C

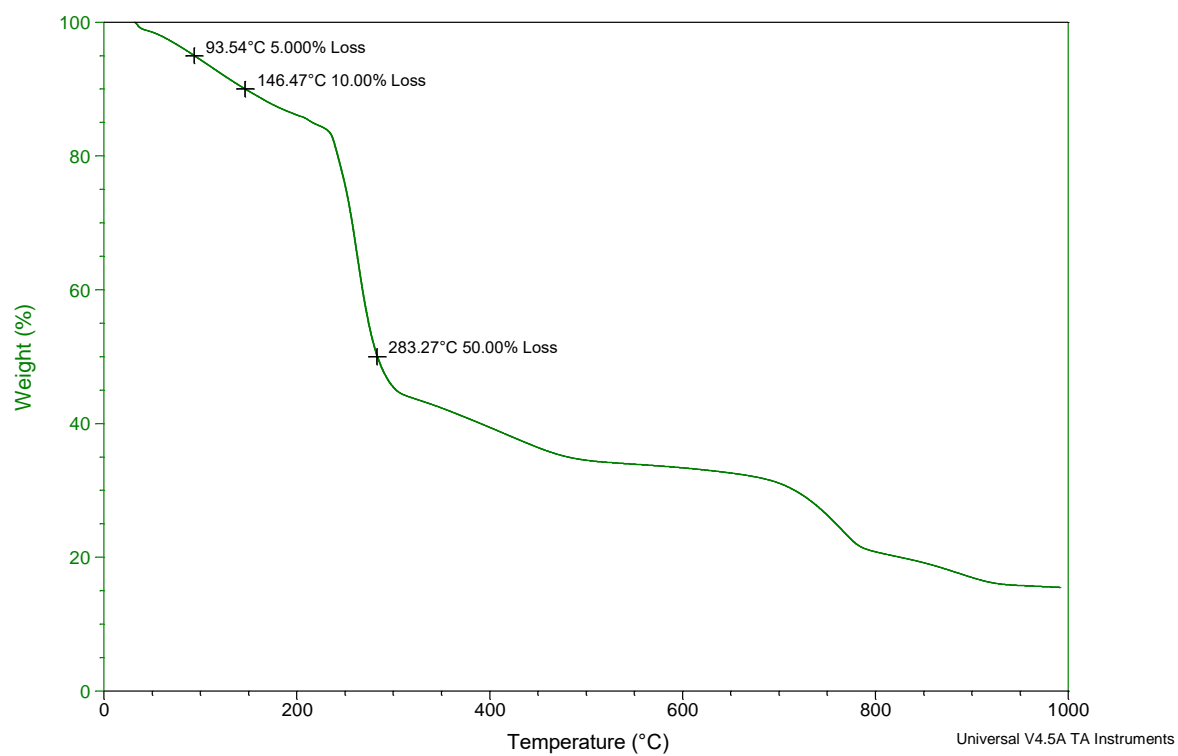


Figure S25. TGA of carboxymethyl starch (CMS).

Sample: 15,04_CMS_powt1
Size: 6.1679 mg

SDT

File: E:\...722020_1213 PM_15,04_CMS_powt1.UA
Operator: KW
Run Date: 02-Jul-2020 14:48

Comment: N2, 10C/min do 1000C

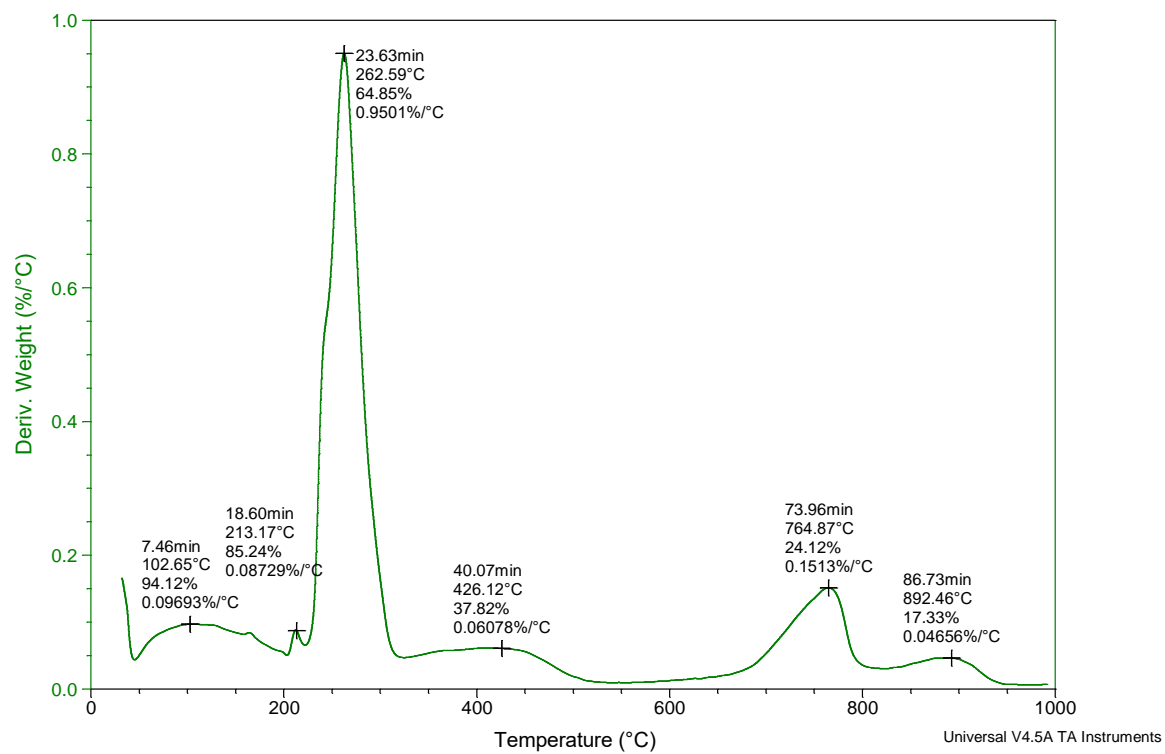


Figure S26. DTA of carboxymethyl starch (CMS).

Sample: ChCl-Su60
Size: 23.4590 mg

SDT

File: E:\...\1302020_1231 PM_ChCl-Su60.UA
Operator: KW
Run Date: 04-Feb-2020 13:57

Comment: AIR, 10C/min do 600C

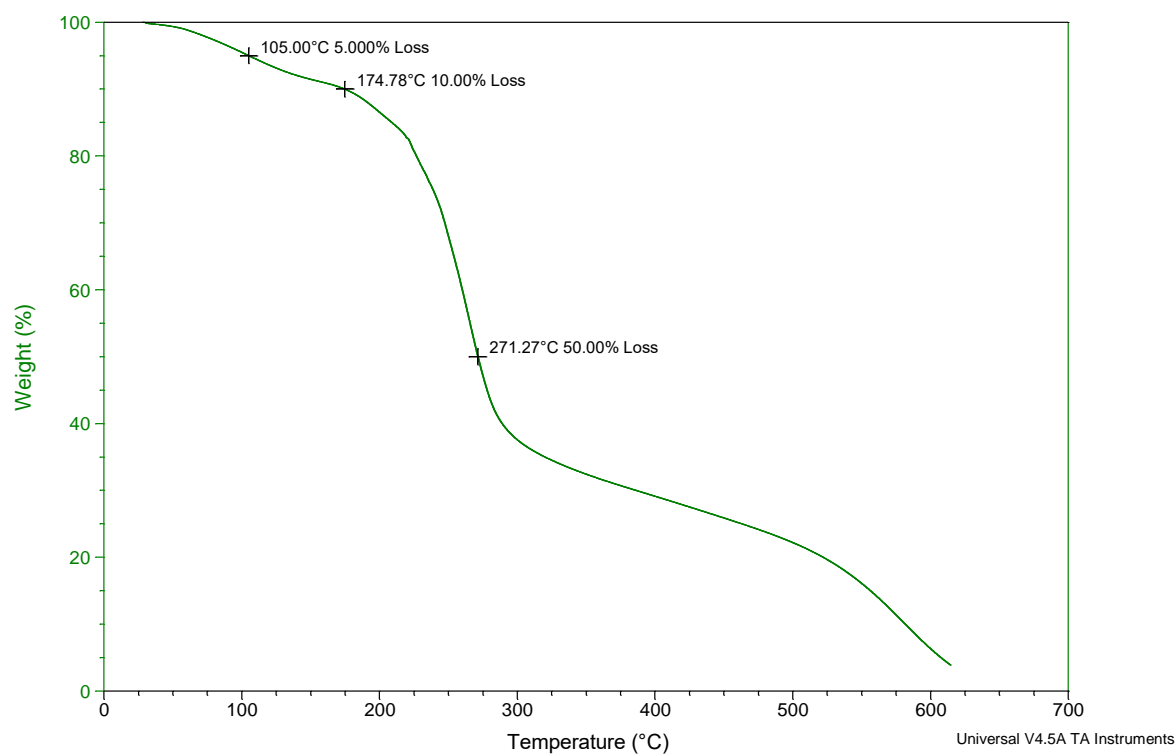


Figure S27. TGA of chitosan (Ch).

Sample: ChCl-Su60
Size: 23.4590 mg

SDT

File: E:\...\1302020_1231 PM_ChCl-Su60.UA
Operator: KW
Run Date: 04-Feb-2020 13:57

Comment: AIR, 10C/min do 600C

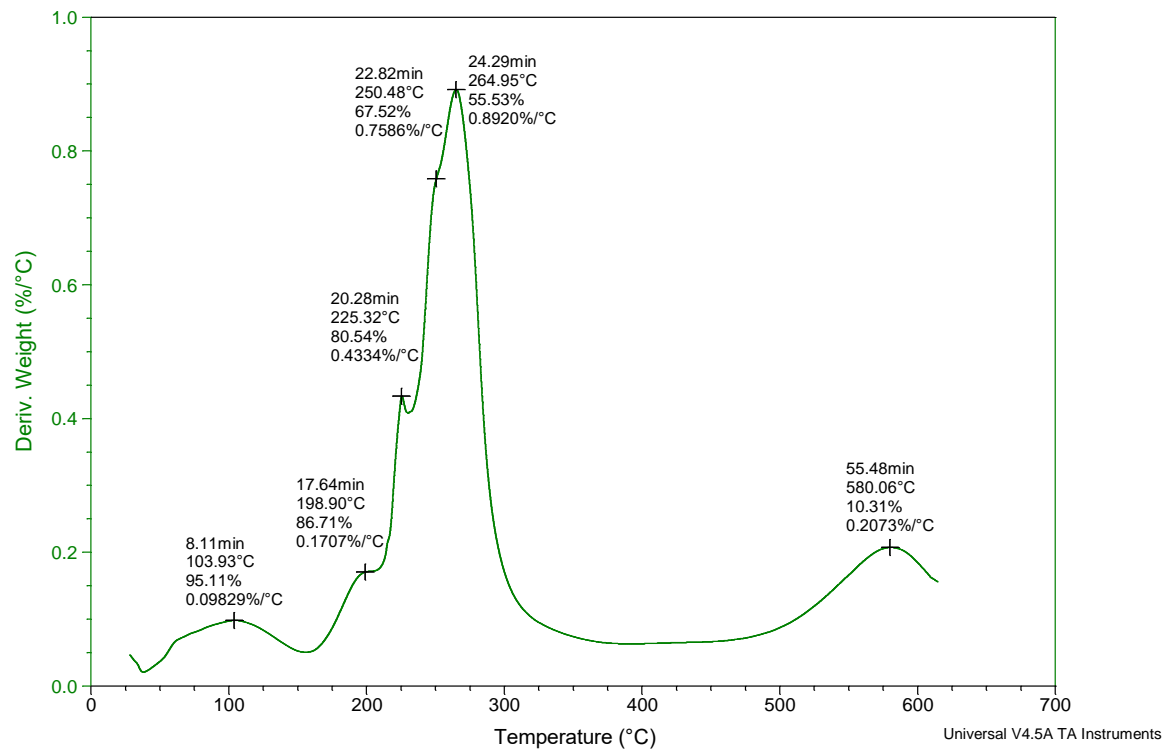


Figure S28. DTA of chitosan (Ch).

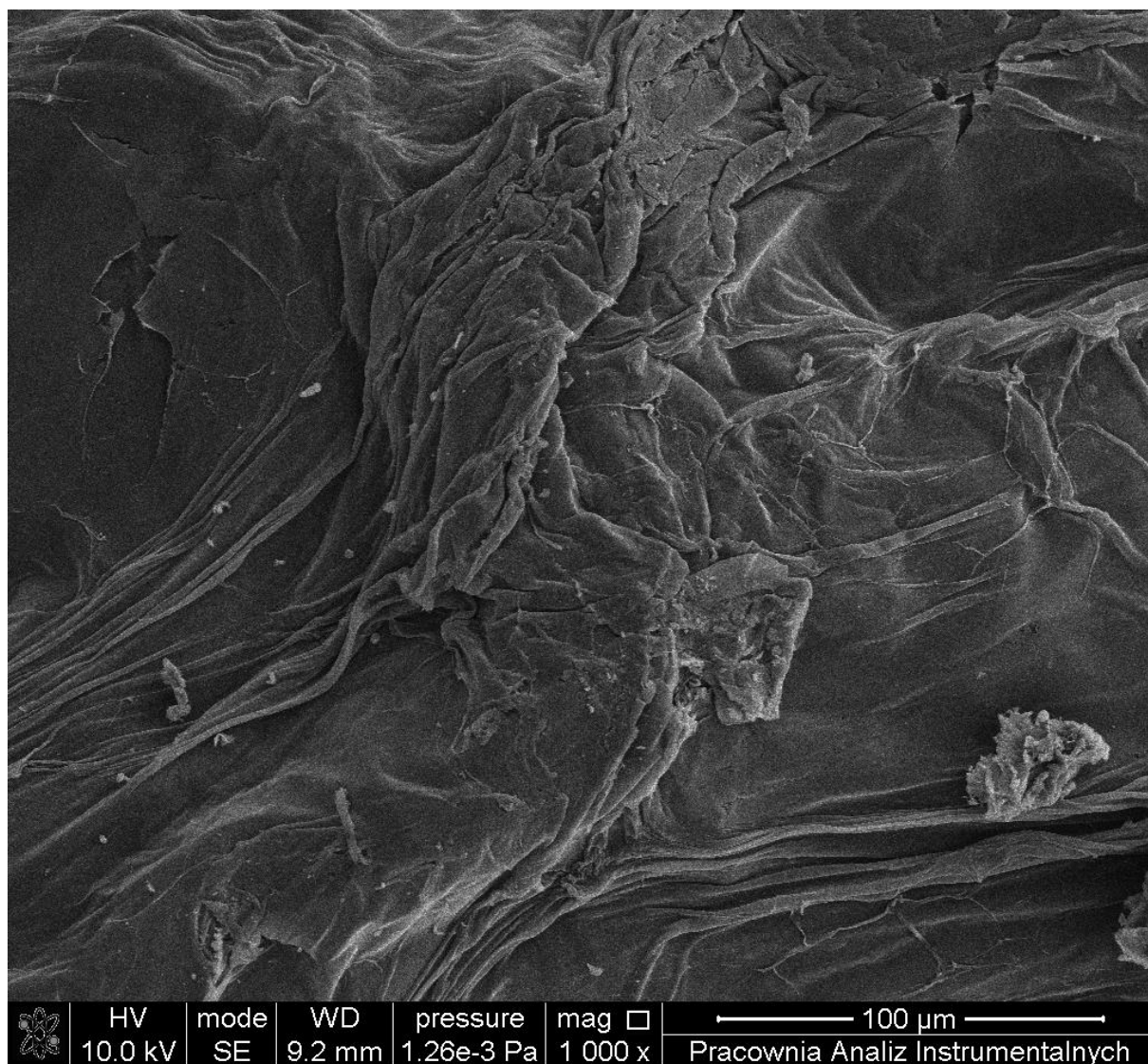


Figure S29. The SEM micrographs with 1000x magnification of CMS-g-Ch without vanillin.

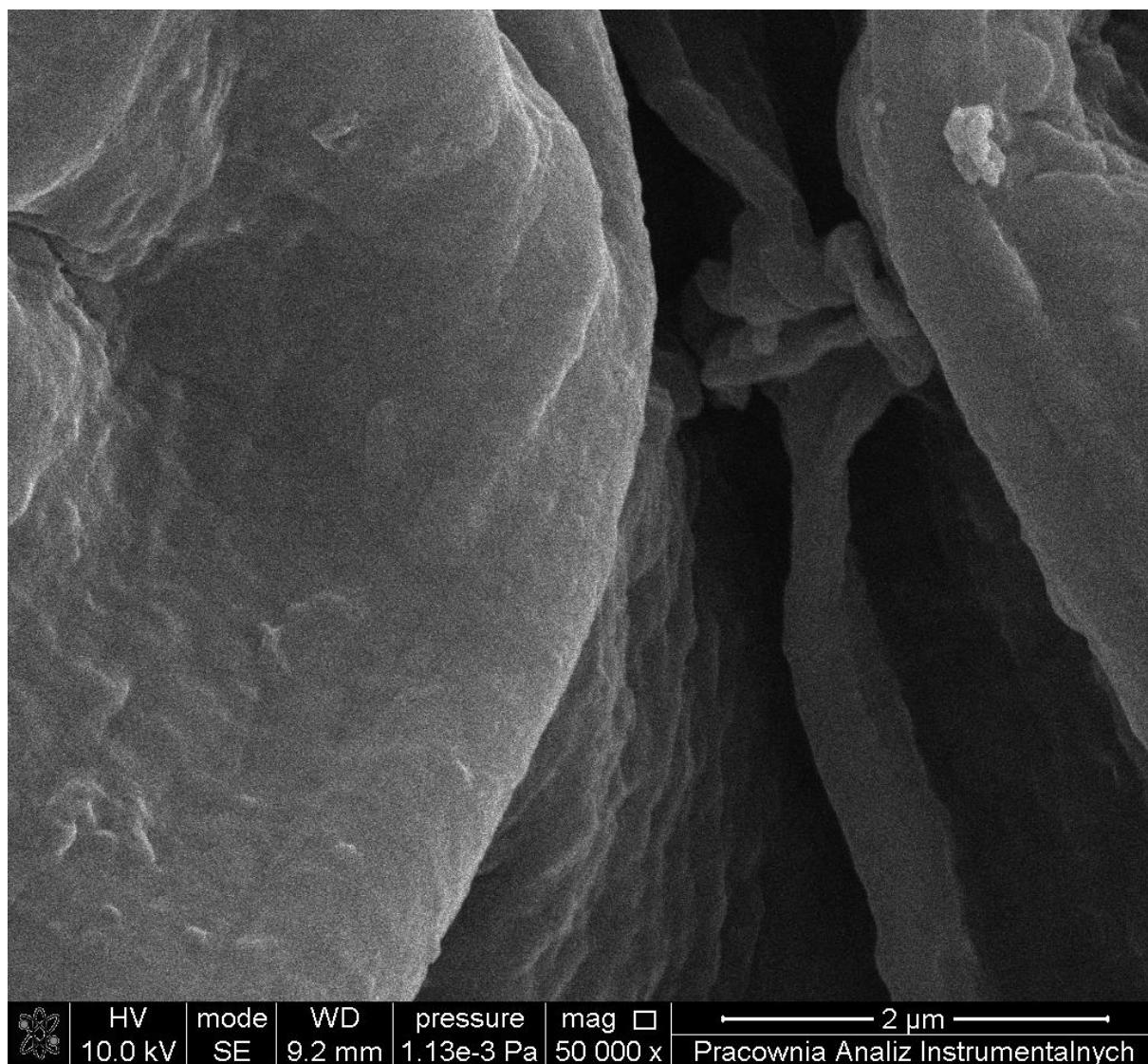


Figure S30. The SEM micrographs with 50000x magnification of CMS-g-Ch without vanillin.

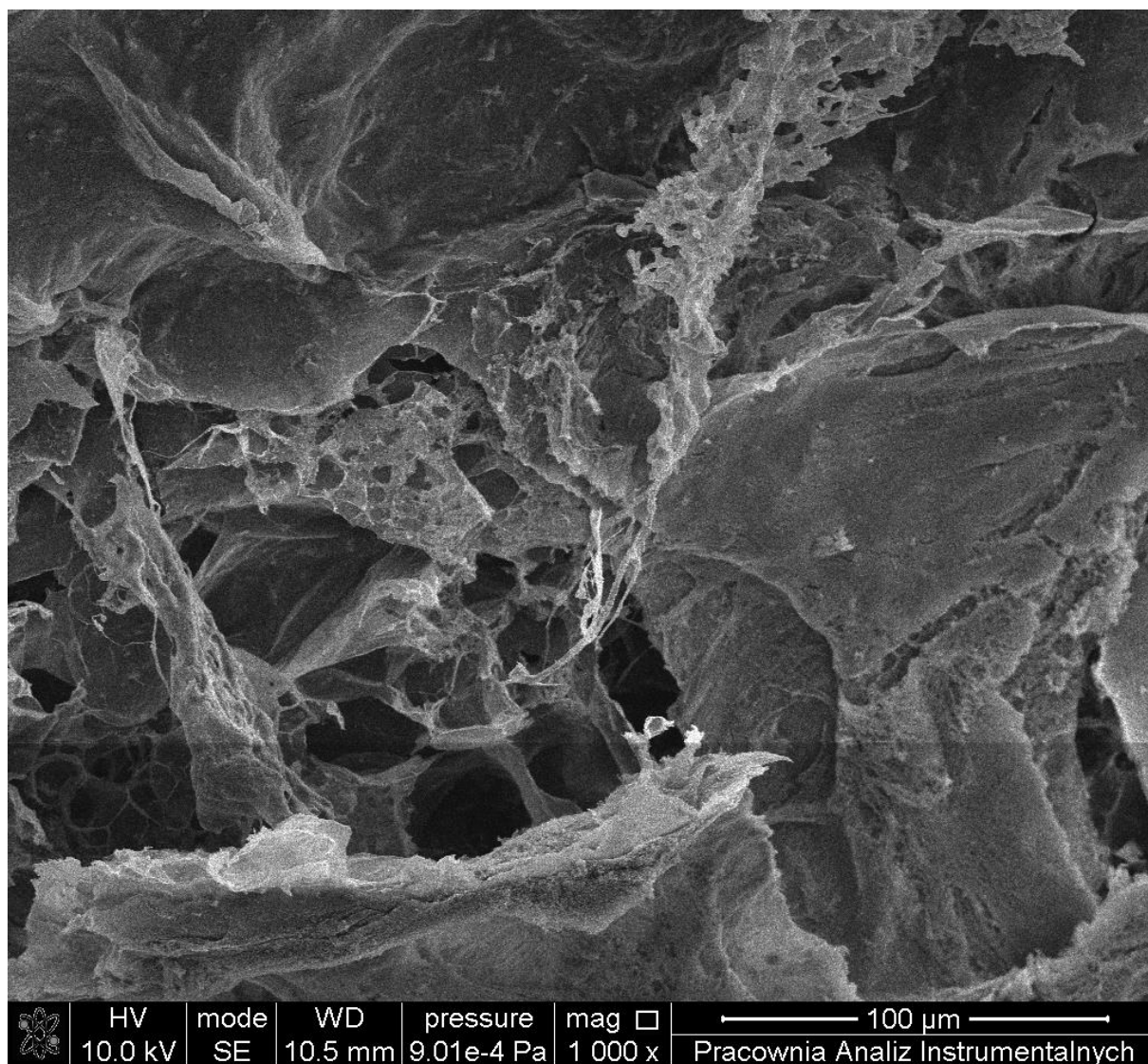


Figure S31. The SEM micrographs with 1000x magnification of CMS-g-Ch with 0,04 vanillin.

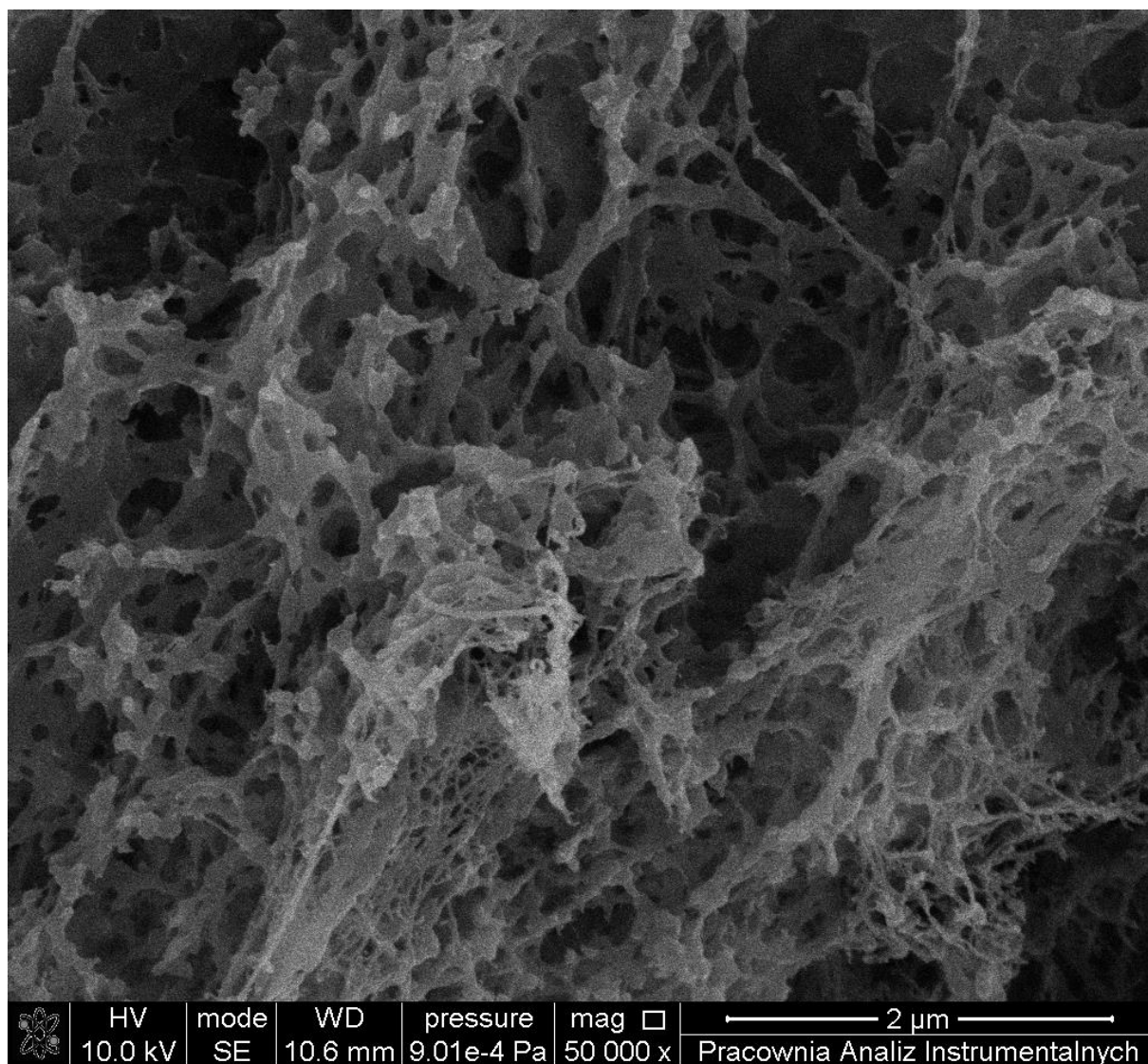


Figure S32. The SEM micrographs with 50000x magnification of CMS-g-Ch with 0,04 vanillin.

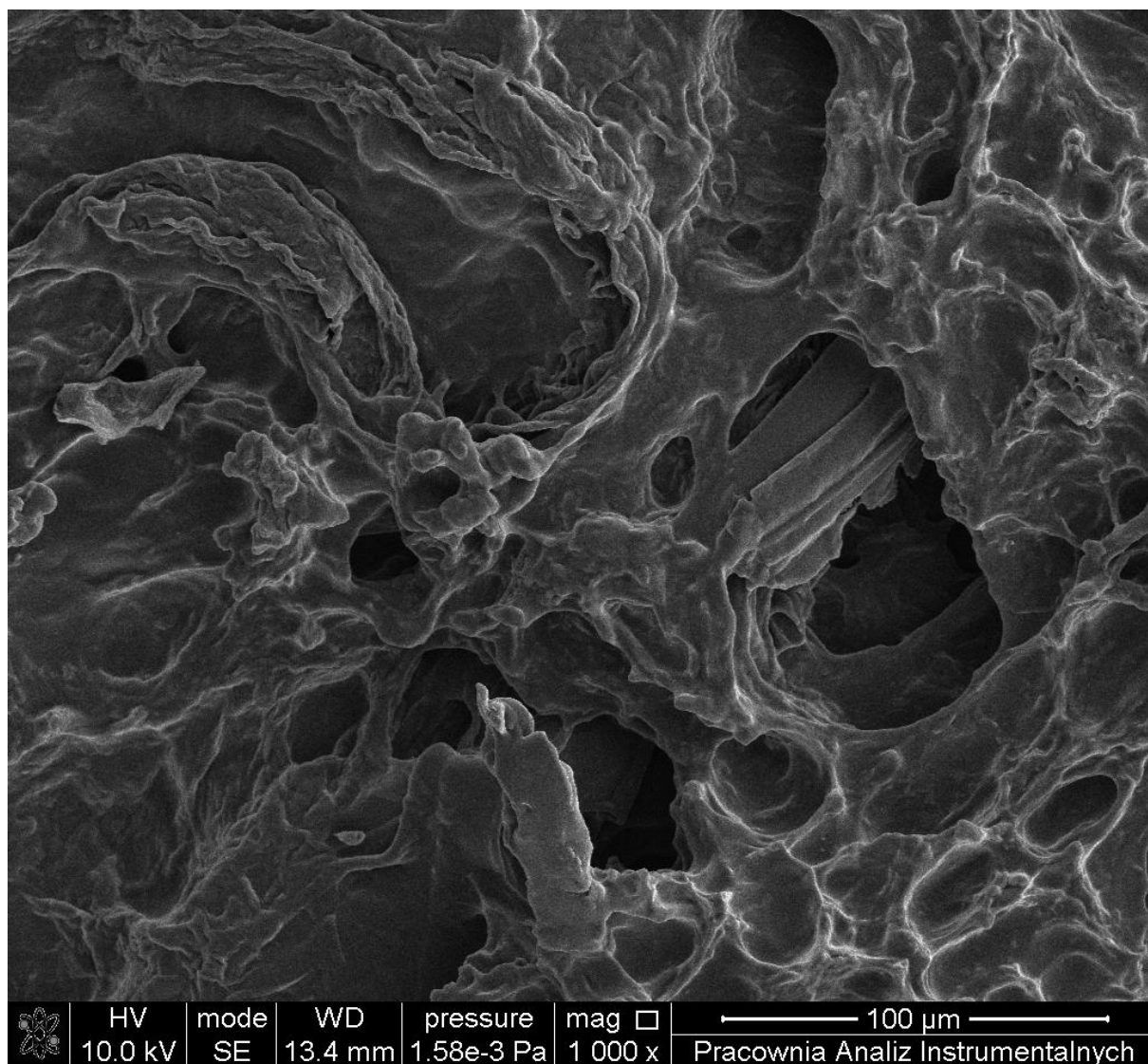


Figure S33. The SEM micrographs with 1000x magnification of CMS-g-Ch with 0,06 vanillin.

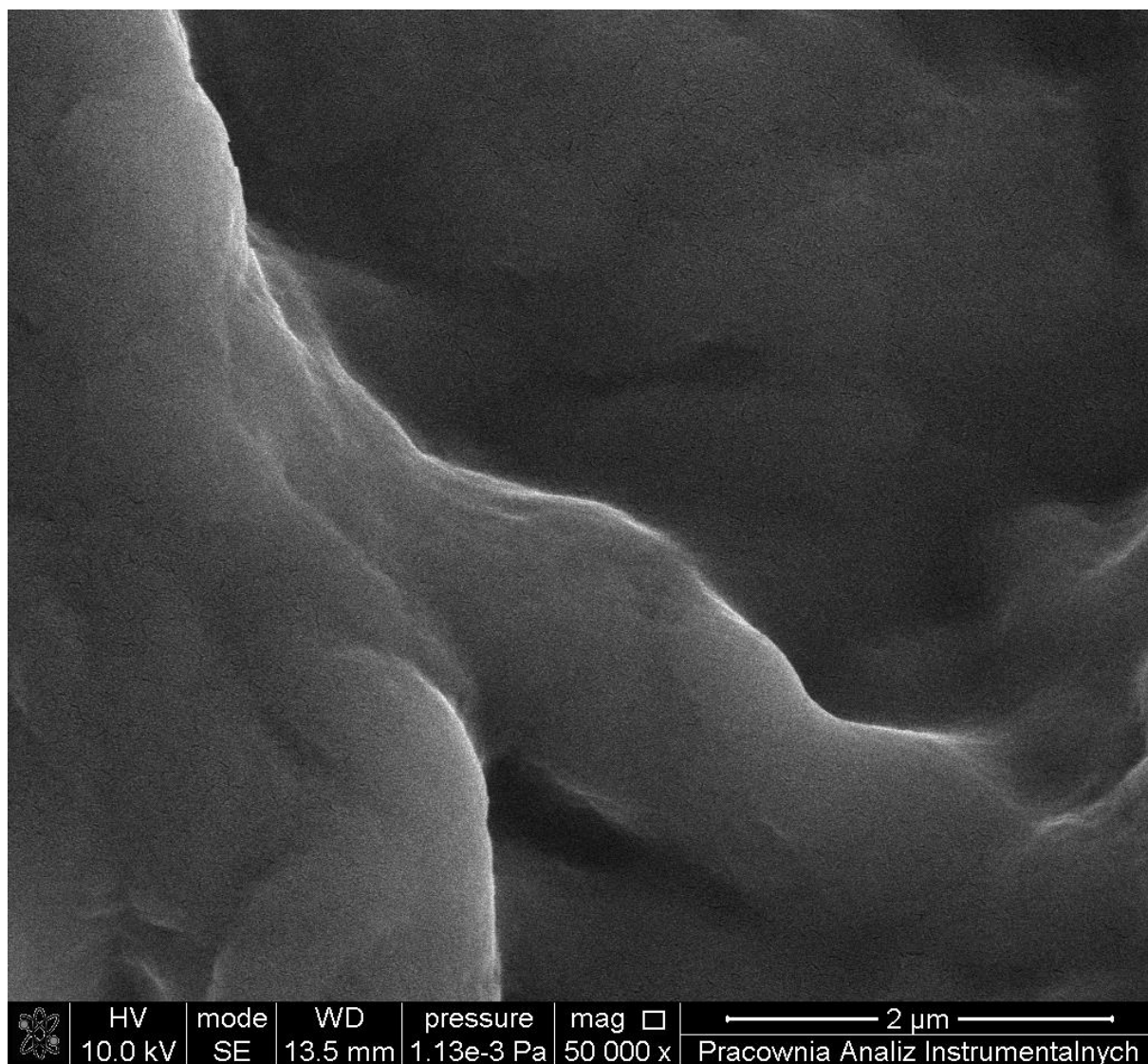


Figure S34. The SEM micrographs with 50000x magnification of CMS-g-Ch with 0,06 vanillin.

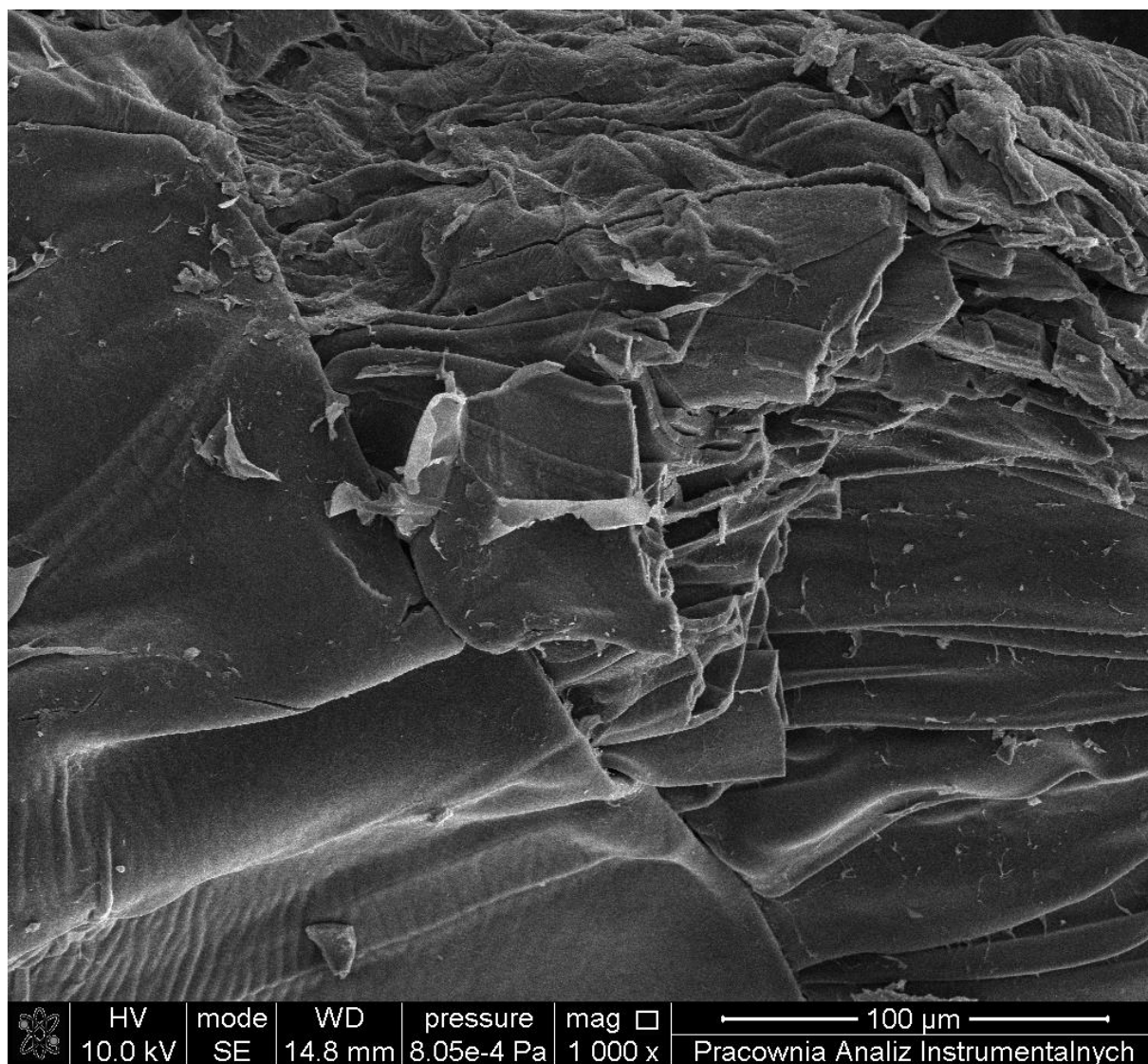


Figure S35. The SEM micrographs with 1000x magnification of CMS-g-Ch with 0,08 vanillin.

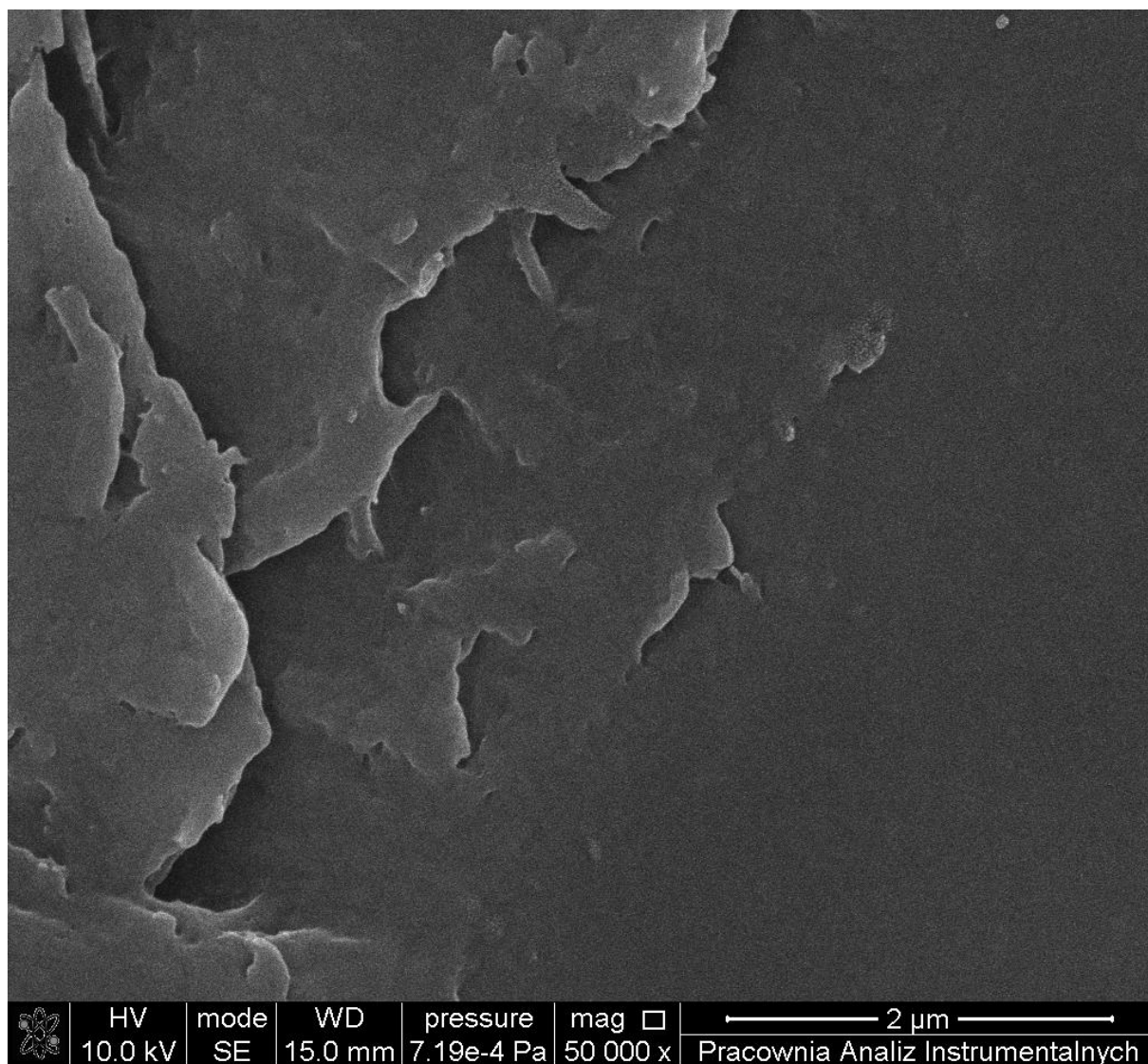


Figure S36. The SEM micrographs with 50000x magnification of CMS-g-Ch with 0,08 vanillin.

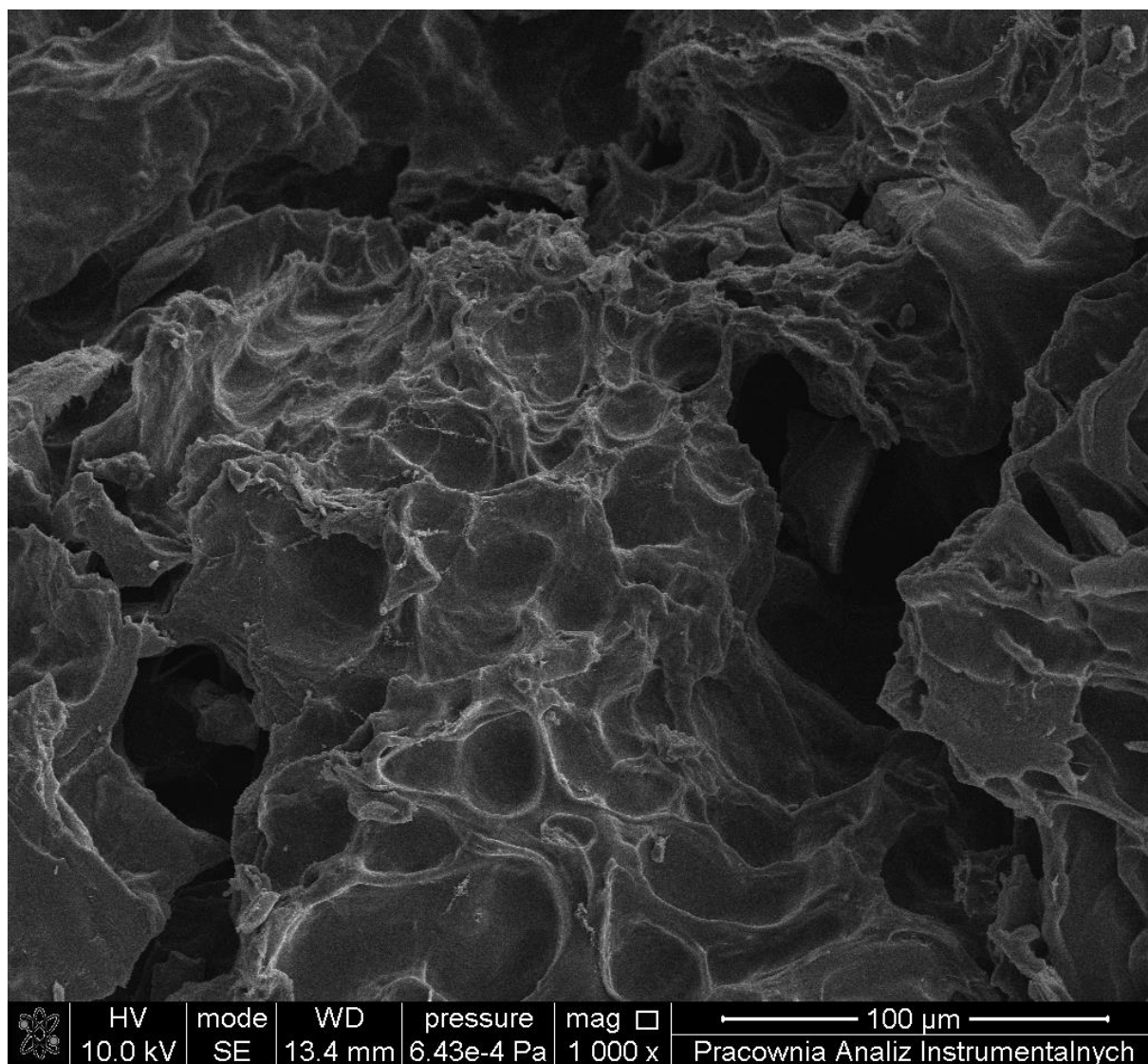


Figure S37. The SEM micrographs with 1000x magnification of CMS-g-Ch with 0,10 vanillin.

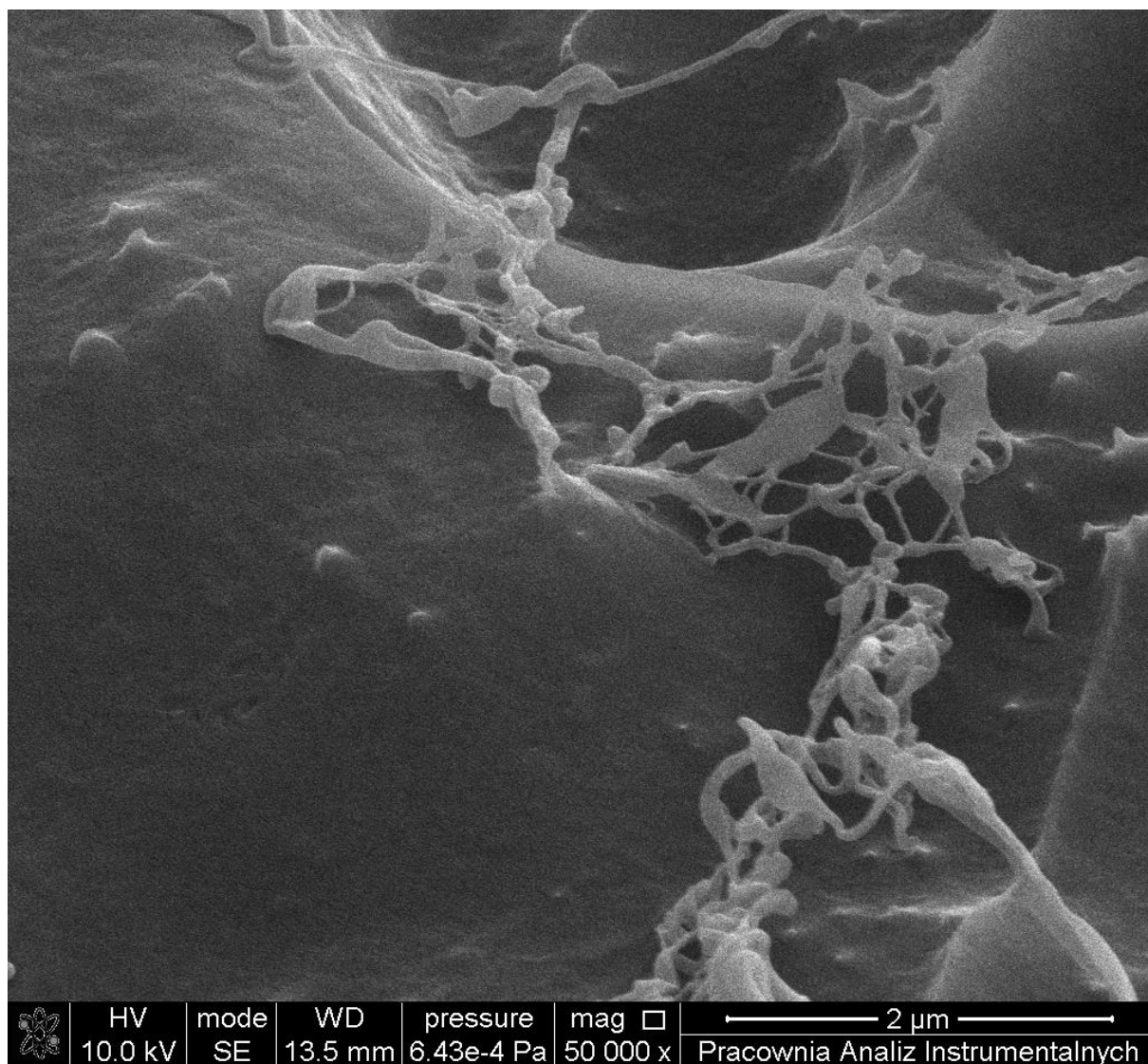


Figure S38. The SEM micrographs with 50000x magnification of CMS-g-Ch with 0,10 vanillin.

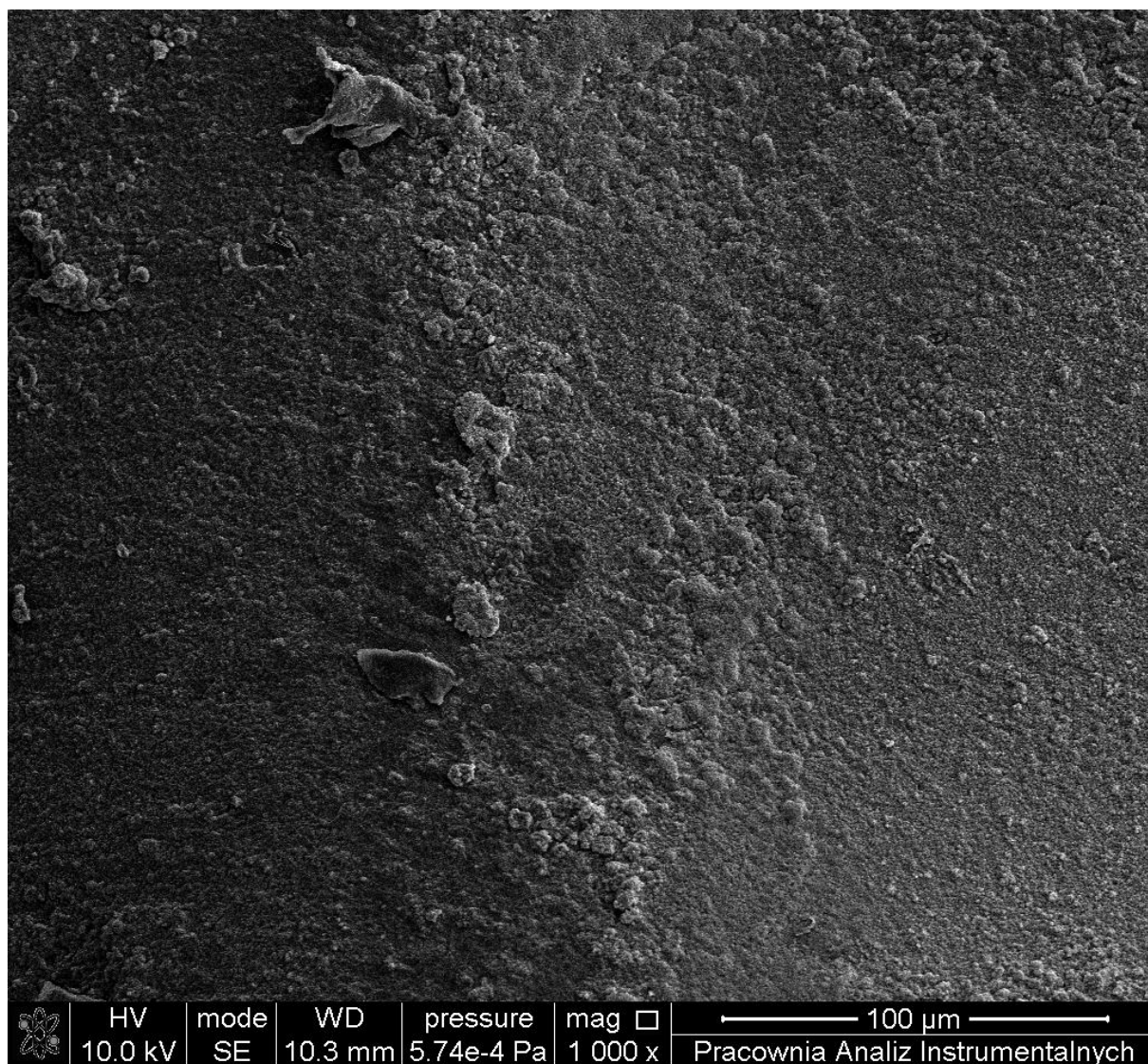


Figure S39. The SEM micrographs with 1000x magnification of CMS.

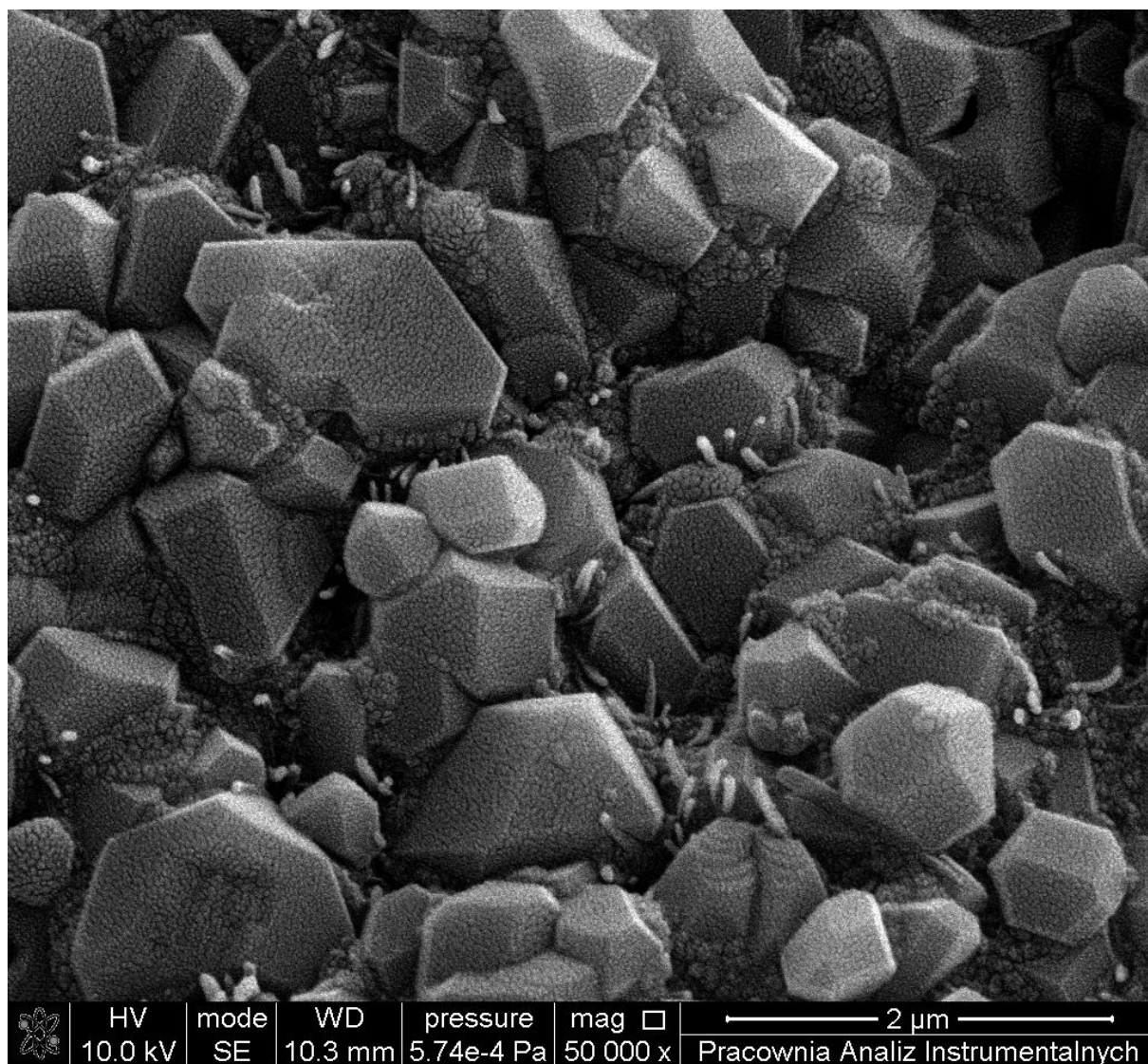
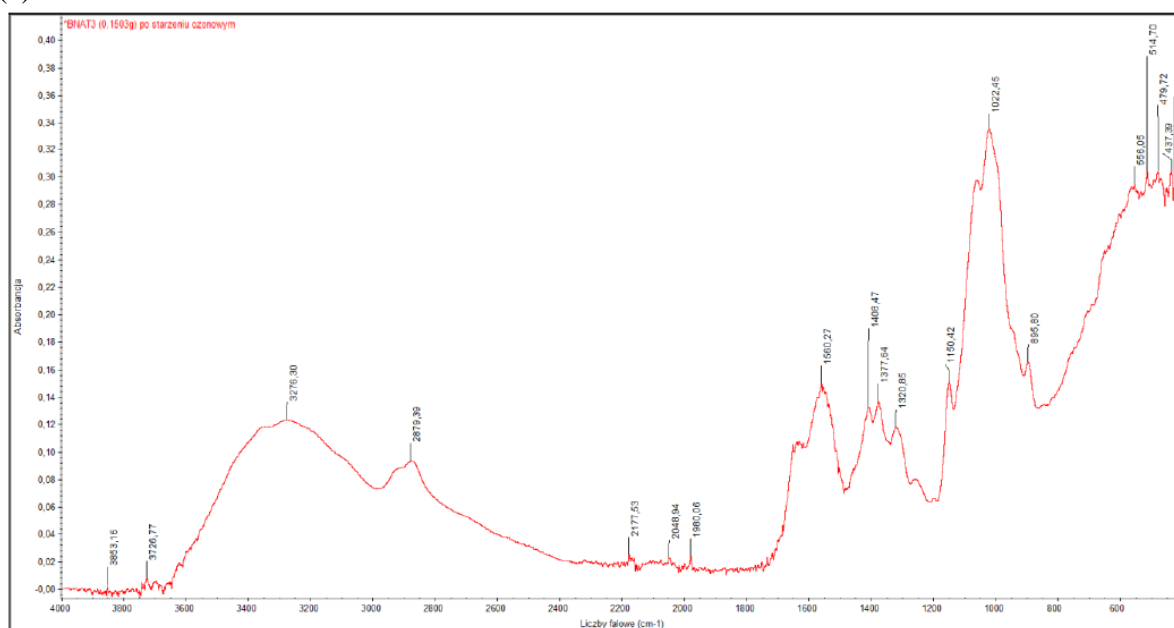


Figure S40. The SEM micrographs with 50000x magnification of CMS.

(a)



(b)

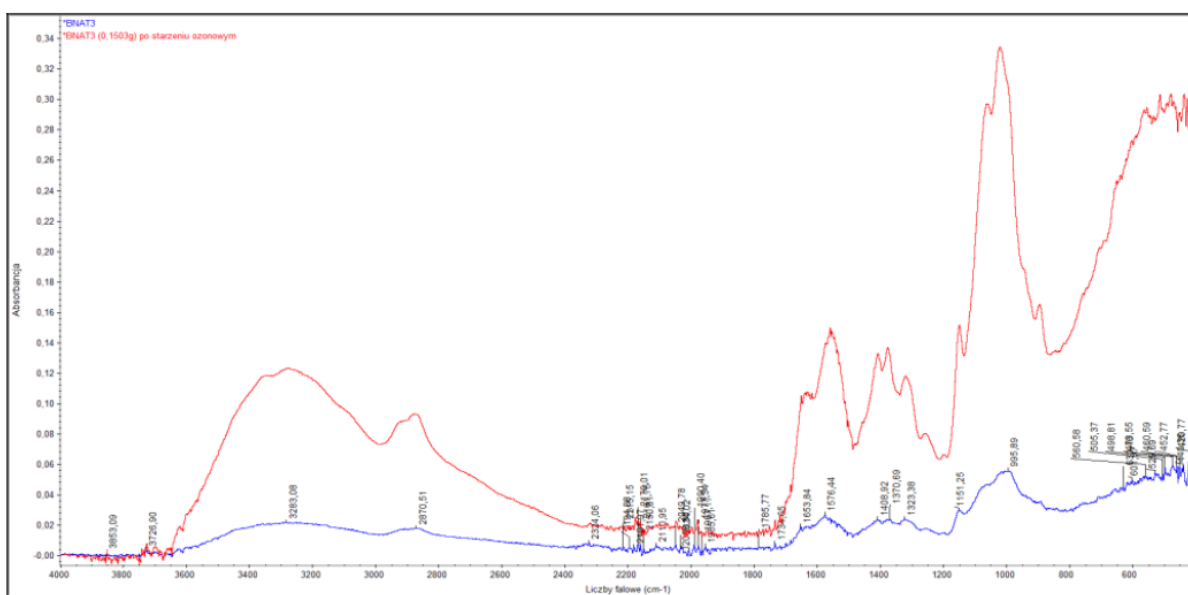
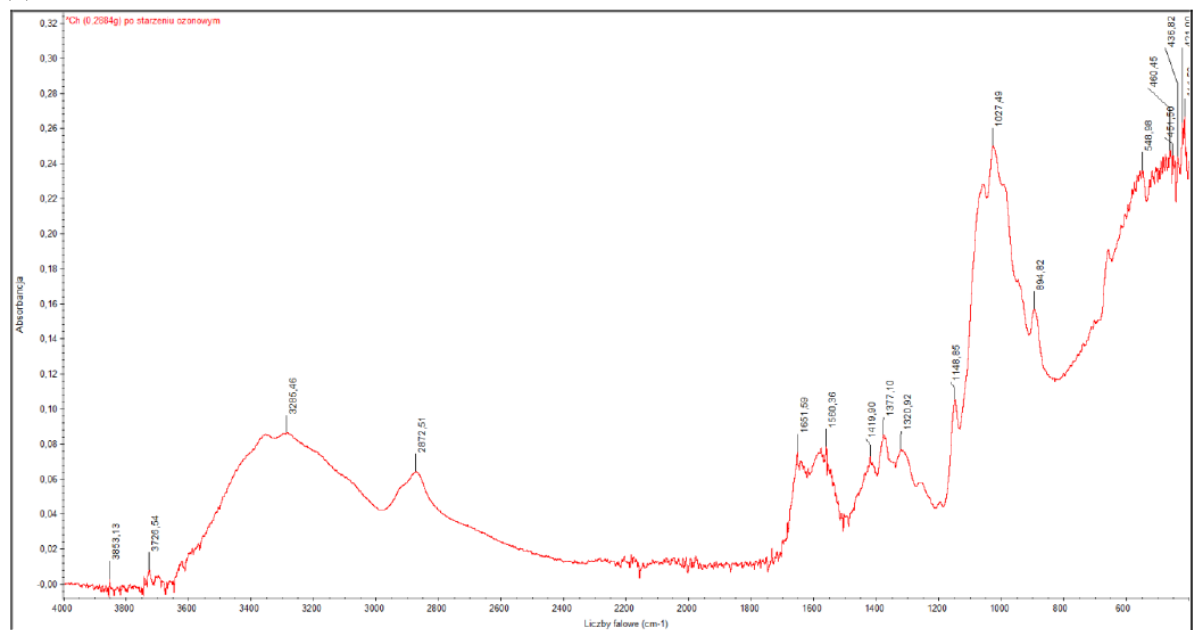


Figure S41. Summary of spectra before (a) and after (b) infrared ozone aging for CMS(1)/Ch(1).

(a)



(b)

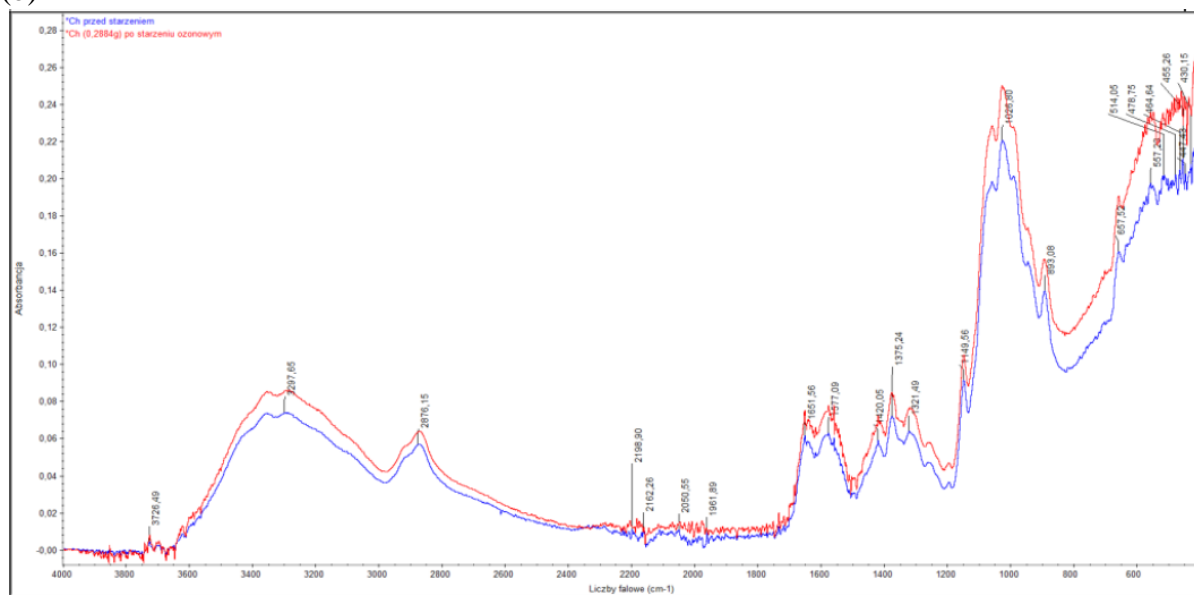
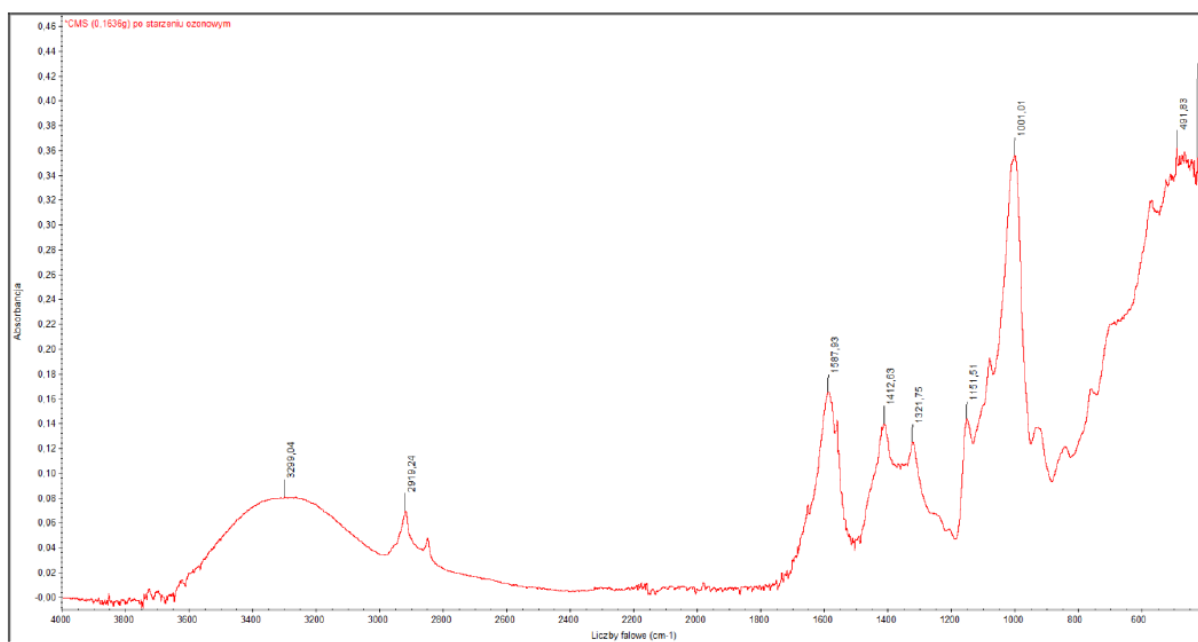


Figure S42. Summary of spectra before (a) and after (b) infrared ozone aging for chitosan (Ch).

(a)



(b)

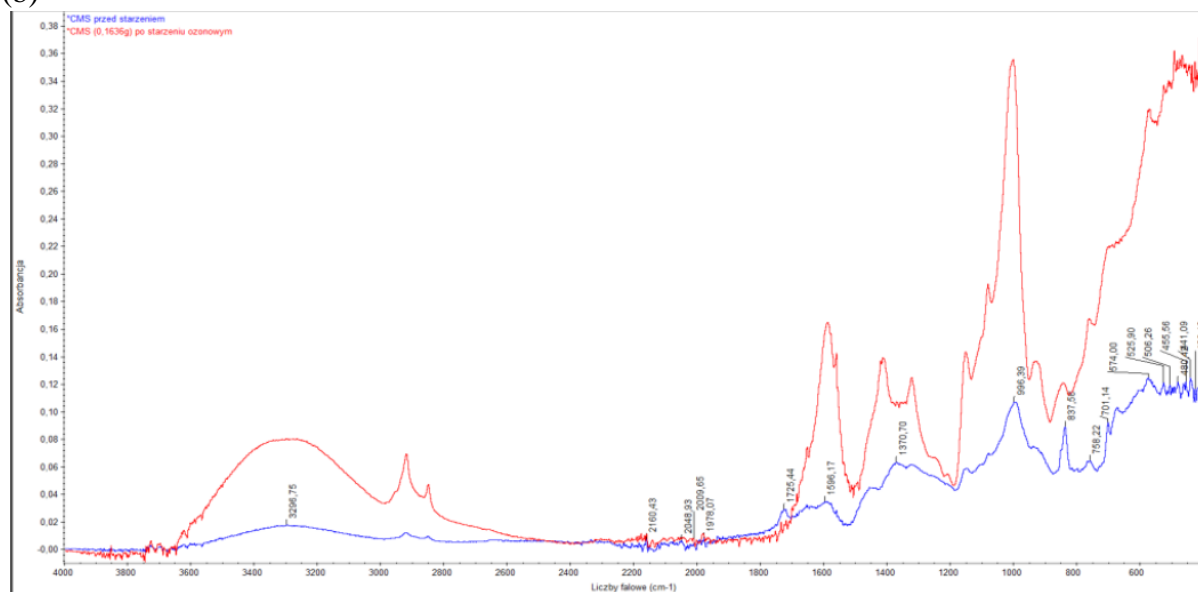
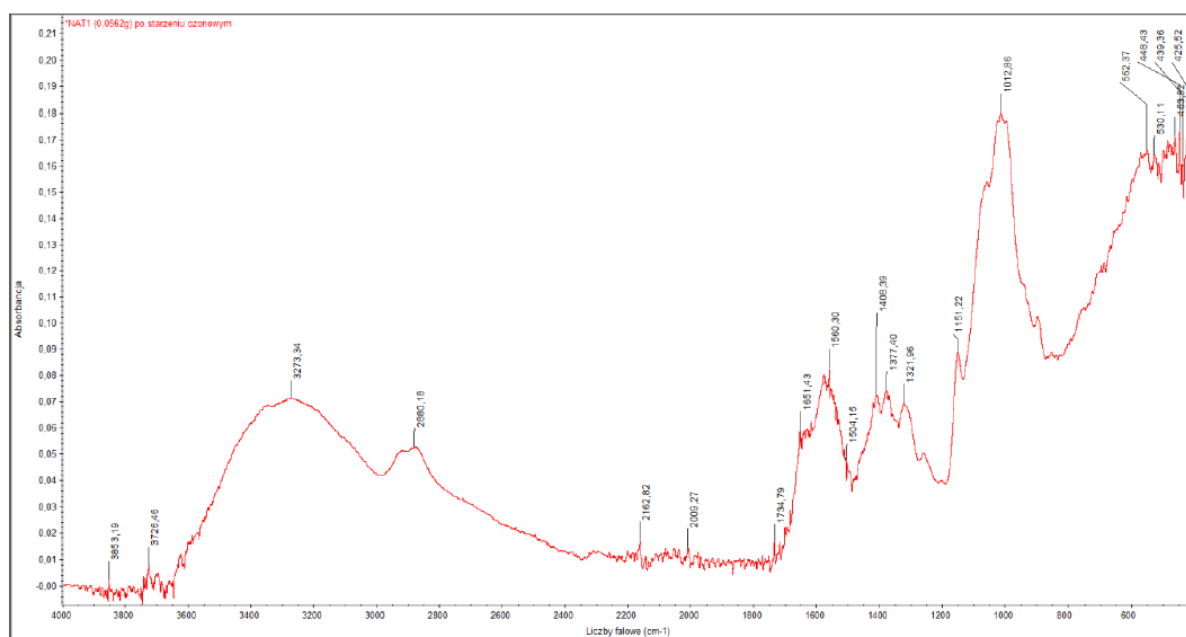


Figure S43. Summary of spectra before (a) and after (b) infrared ozone aging for carboxymethyl starch (CMS).

(a)



(b)

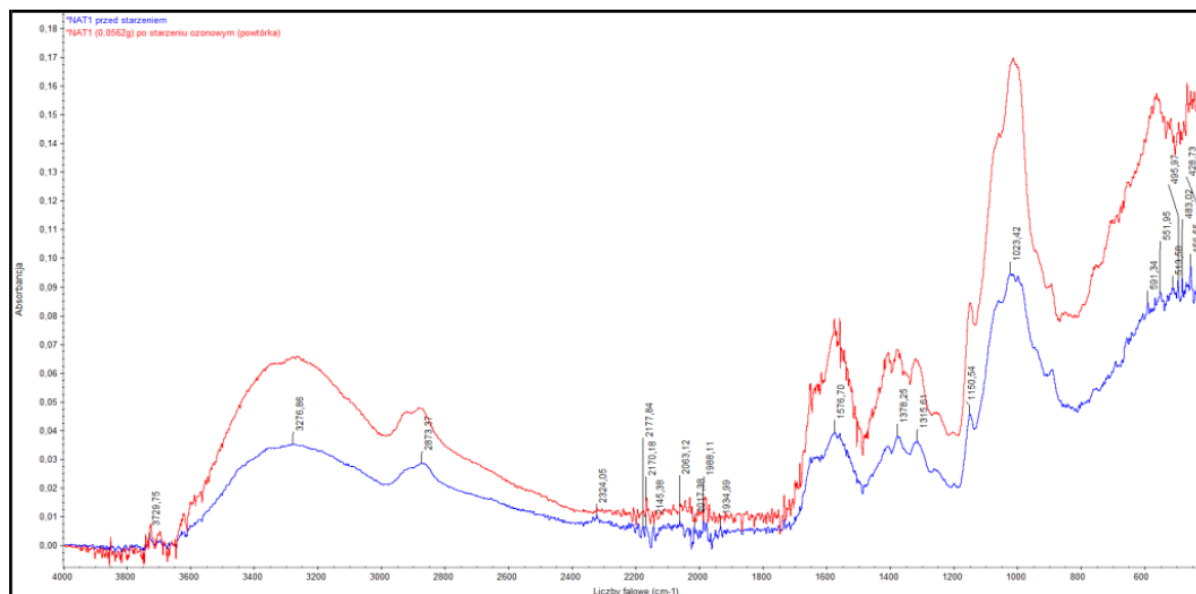
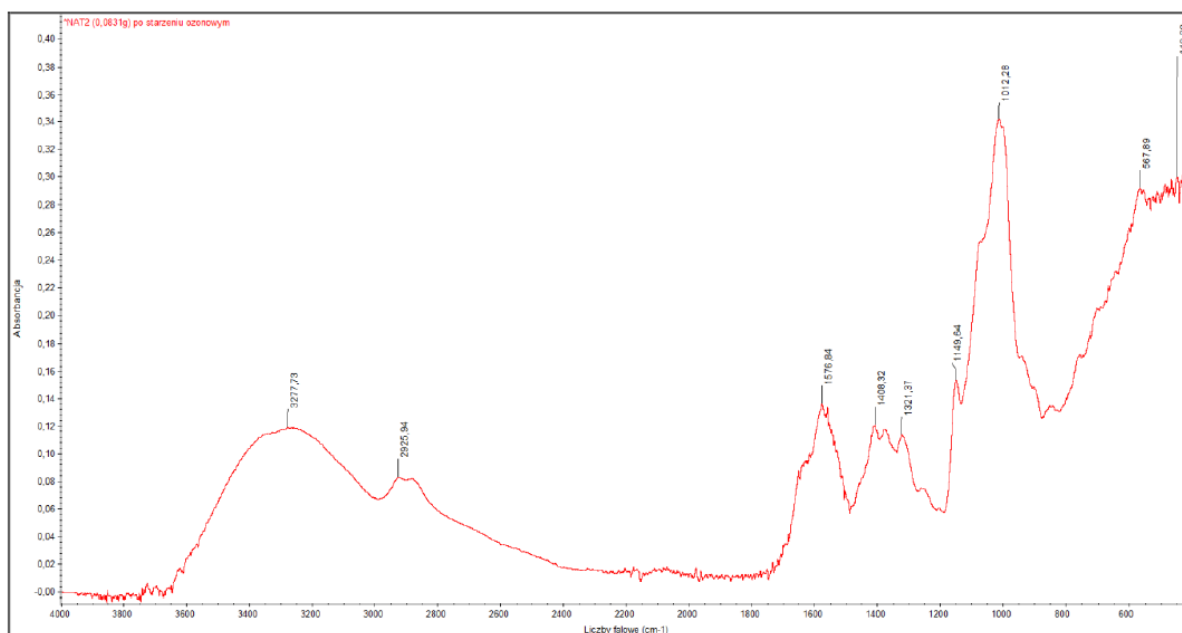


Figure S44. Summary of spectra before (a) and after (b) infrared ozone aging for CMS(1)/Ch(1)/Van(0,04).

(a)



(b)

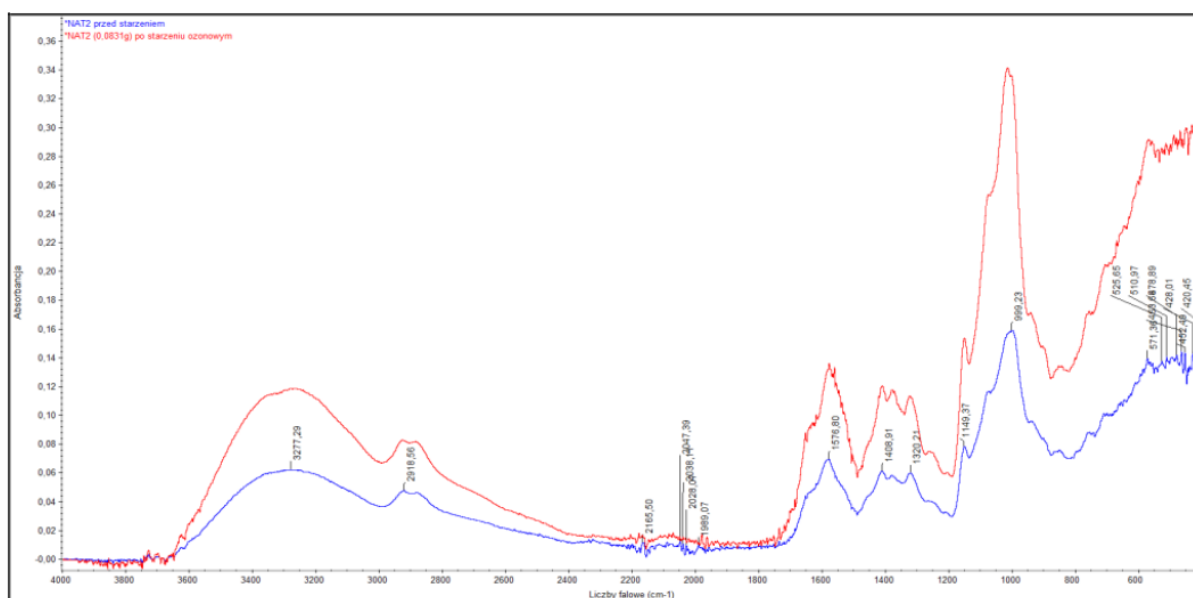


Figure S45. Summary of spectra before (a) and after (b) infrared ozone aging for CMS(1)/Ch(1)/Van(0,08).

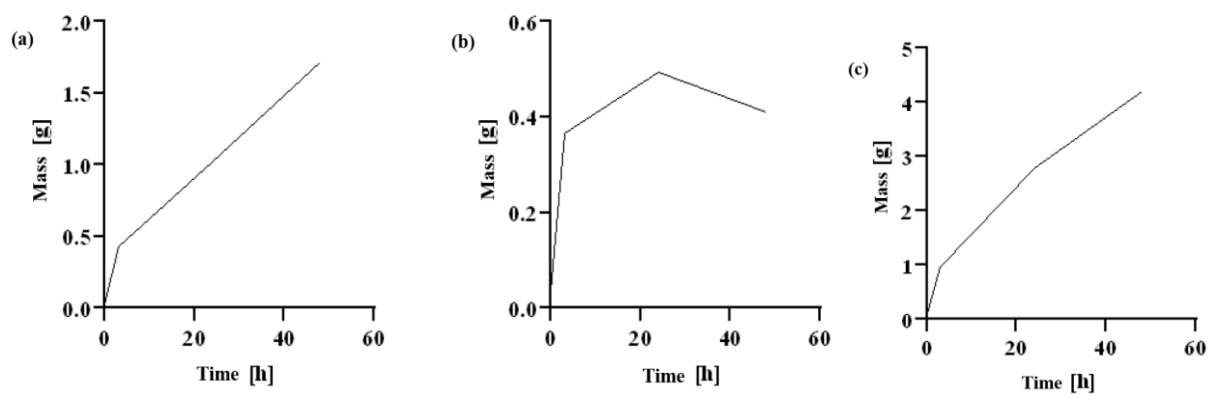


Figure S46. Time dependence of surface water absorption by the tested polymers: (a) CMS(1)/Ch(1)/Van(0,04); (b) CMS(1)/Ch(1)/Van(0,08); (c) CMS(1)/Ch(1).



















Name sample	The process of preparing modular and seed material	Prepared composition	The process of germination on a given material
Native sample			
CMS(1)/Ch(1)/ Van(0.04)			
CMS(1)/Ch(1)/ Van(0.08)			
Chitosan			
CMS			
CMS(1)/Ch(1)			

Figure S47. Sowing plants from the OECD group in containers with modular material and the germination process.

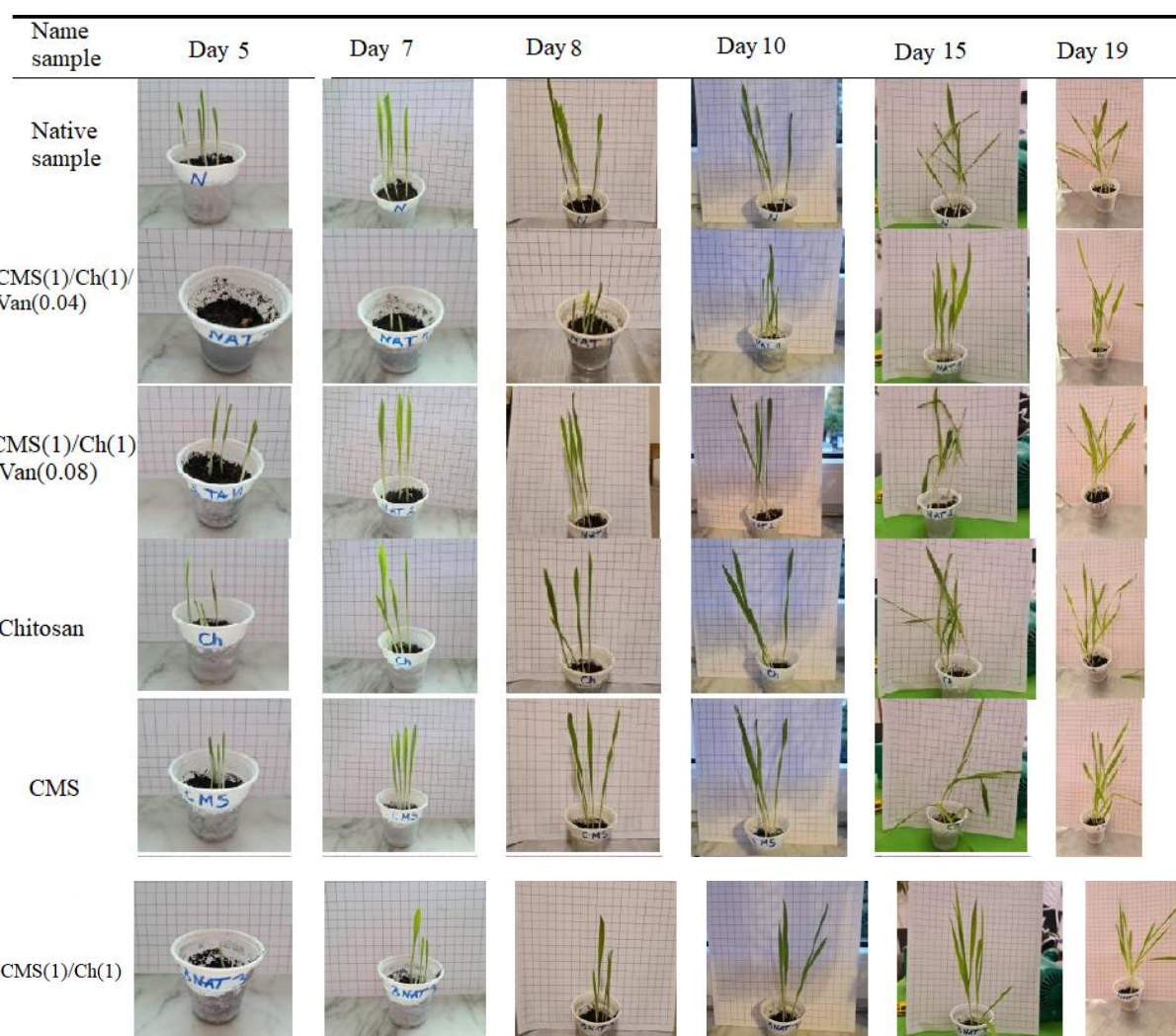
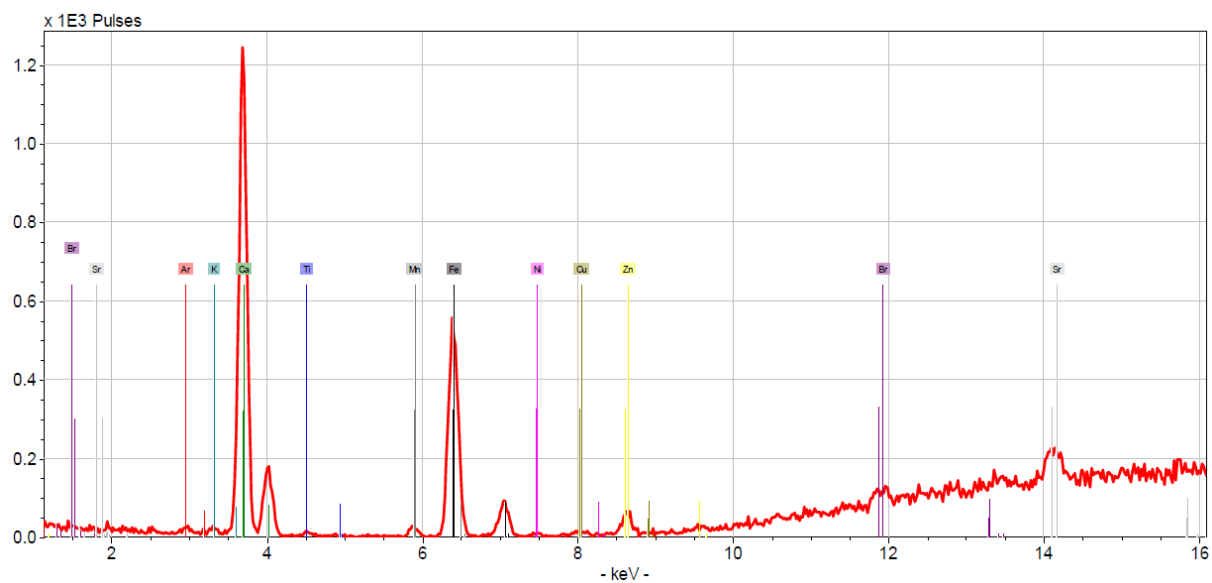
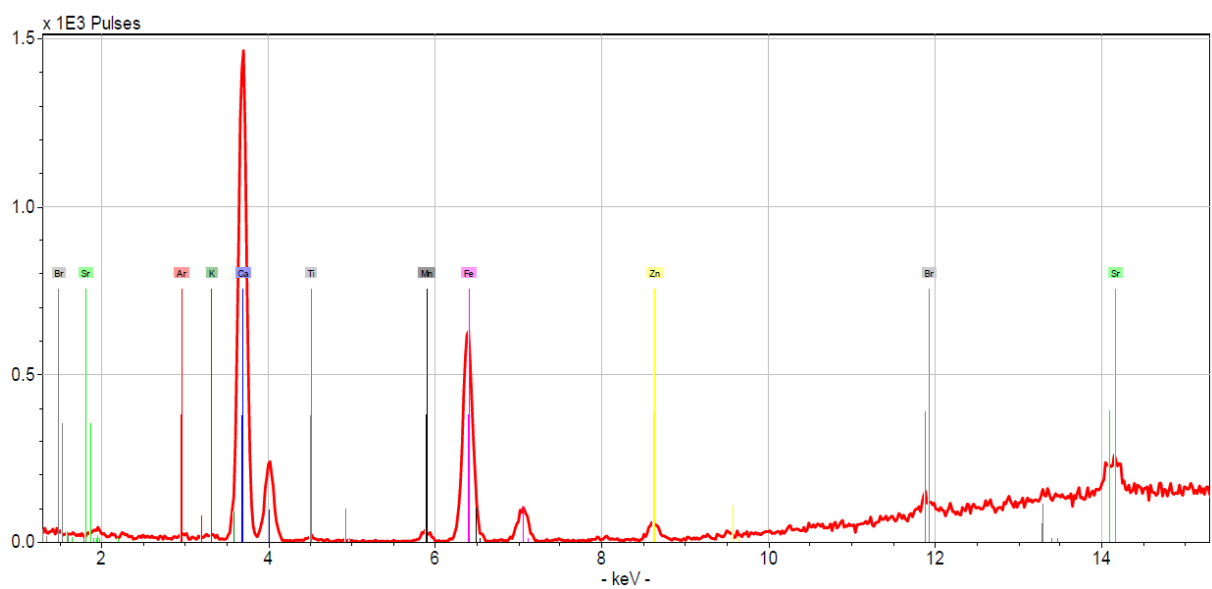


Figure S48. Further growth of OECD plants with tested polymers.

(a)



(b)



(c)

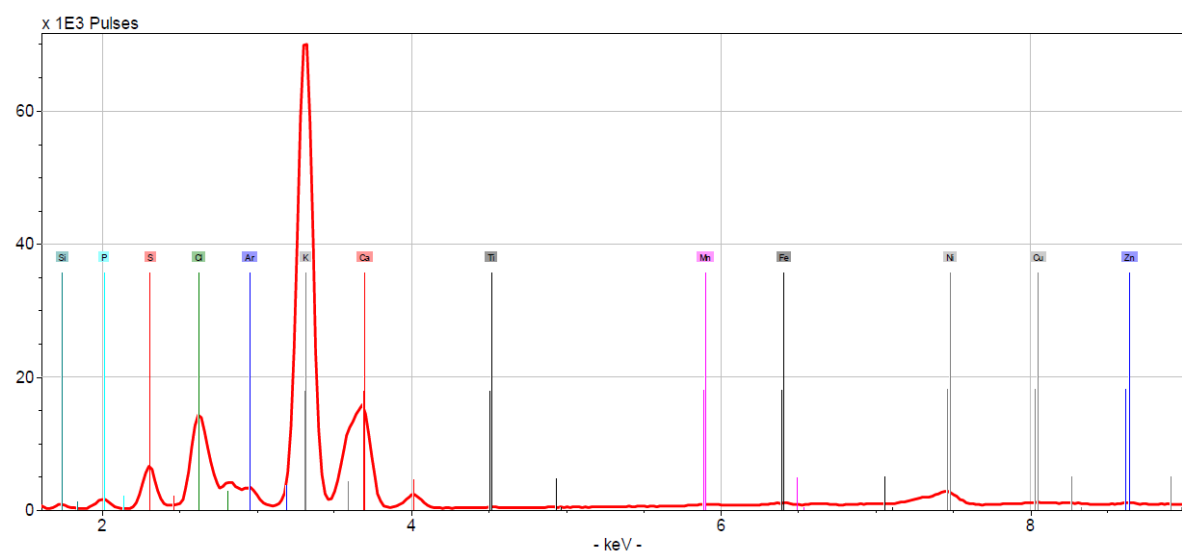


Figure S49. X-ray fluorescence spectroscopy (XRF) spectra for (a) CMS in soil; (b) CMS(1)/Ch(1)/Van (0.04) in soil; (c) CMS(1)/Ch(1)/Van(0.04) in straw.