Supporting Information

Two-Dimensional Co-Compounded Carbonaceous Nanoplates for Rubber Tire Composites with Enhanced Mechanical Properties

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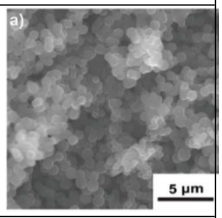
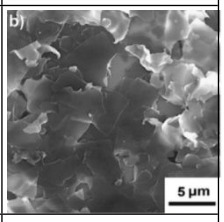
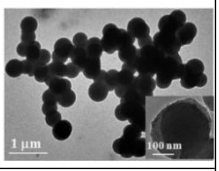
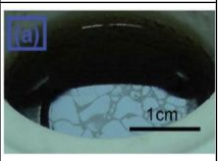
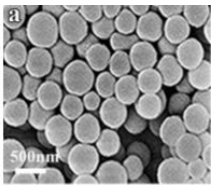
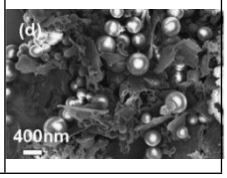
Figure S1. (a)Raw materials of glucose and DHB (b) Glucose + DHB solution dispersed at 80 wt% at room temperature, and (c) 80 wt% glucose + DHB solution heated in a water bath(90°C)

Table S1. There have been several attempts to synthesize carbonaceous materials using only glucose through hydrothermal treatment [1-8]. However, when glucose is used as single precursor material, it was confirmed that carbon spheres were synthesized. To synthesize a two-dimensional material with glucose, a mixture of glucose and graphene oxide (graphene oxide used as a frame material) was used. However, our group firstly reported a method of synthesizing two-dimensional carbonaceous nanoplates using only glucose in 2019 [9].

Ref. No	Precursor source	Method	Temp.	Synthesized Material	Dimension	C/O ratio	Images
1	Glucose	Hydrothermal	180°C	Carbon sphere	~1 μm	1.8	
	Glucose+GO	Hydrothermal	180°C	Carbon nanosheet	t : 40 nm L : 4 μm	4.5	
2	Glucose	Hydrothermal	200°C	Carbon sphere	~ 500 nm	-	
3	Glucose	Hydrothermal	160-220°C	Carbon nanosheet	t : 25 nm L : ~100 μm	2.8	
4	Glucose	Hydrothermal	180°C	Carbon sphere	~500 nm	-	
5	Glucose	Hydrothermal	180°C	Carbon sphere	~ 500 nm	1.75	

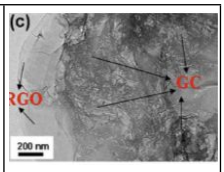
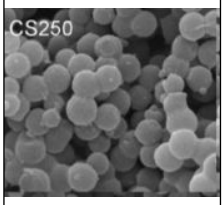
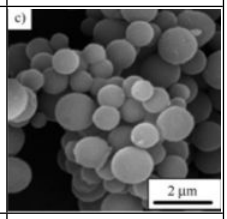
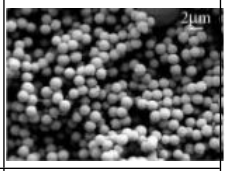
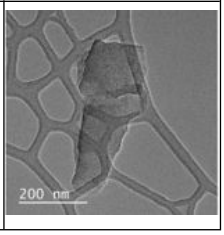
	Glucose+GO	Hydrothermal	180°C	Carbon nanosheet	-	3.46	
6	Glucose	Hydrothermal	180-290°C	Carbon sphere	400-1200 nm	2.13-3.38	
7	Glucose	Hydrothermal	170-240°C	Carbon sphere	300-1300 nm	2.80-2.96	
8	Glucose	Hydrothermal	160-180°C	Carbon sphere	150-1500 nm	-	
9	Glucose (CANP)	Hydrothermal	210°C	Carbon nanosheet	t : 1.3 nm L :725 nm	-	

Figure S2. Results of hydrothermal process using (a) glucose only (b) DHB only, and (c) mixture of glucose and DHB (We call this Co-CANP in this paper). All the samples are prepared using the same amounts of source materials (80 wt%).

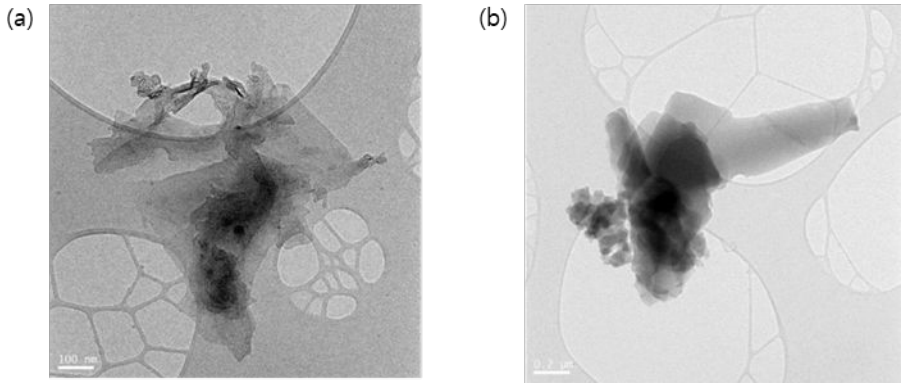


Figure S3. TEM images showing a two-dimensional Co-CANP layered in multiple layers.

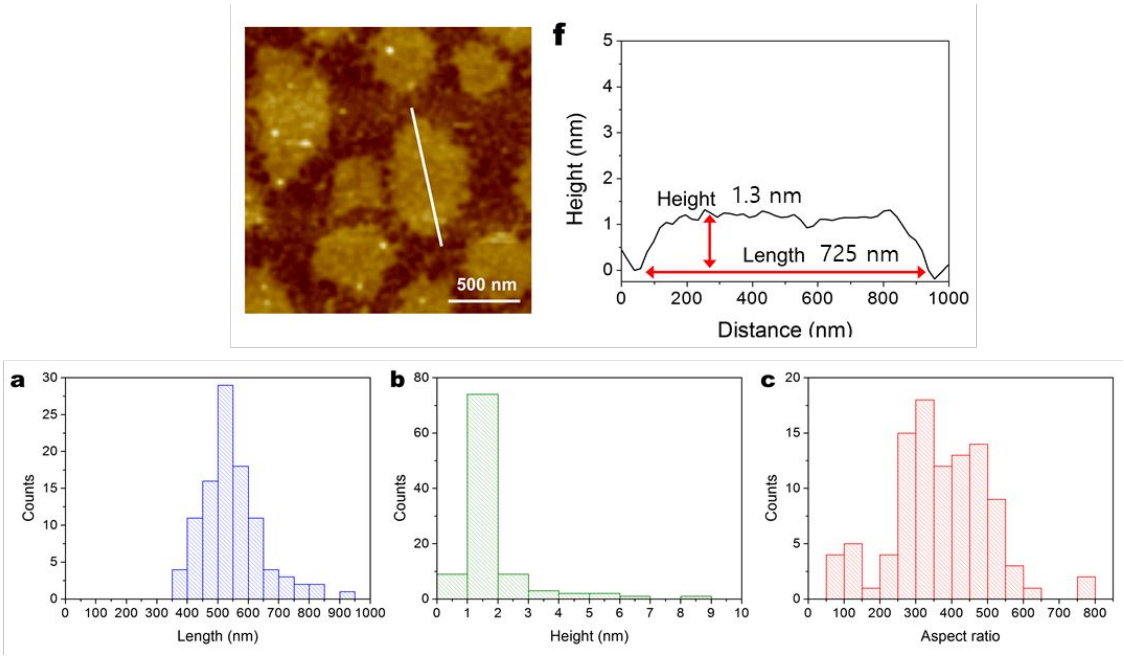


Figure S4. Morphological charateristics of CANP (synthesized using glucose only). The average height is 1.3 nm and the average length is 380 nm, with an average aspect ratio of 292.3 [9].

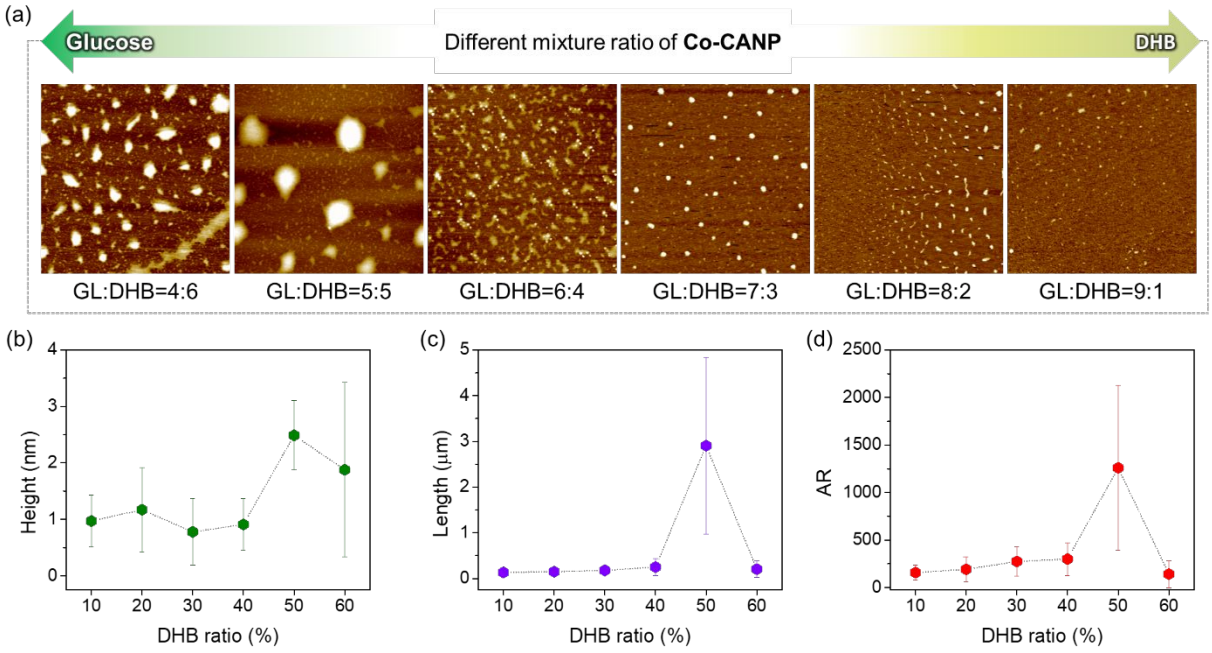


Figure S5. a) 5 μm scan-size images of AFM for Co-CANP for various mixing ratios of glucose to DHB. b-d) Changes in height, length, and aspect ratio of Co-CANP as affected by the DHB mixing ratio.

Figure S6. Dissolving 1mg/ml of Co-CANP in 20 kinds of organic solvents (more polar to the right side)

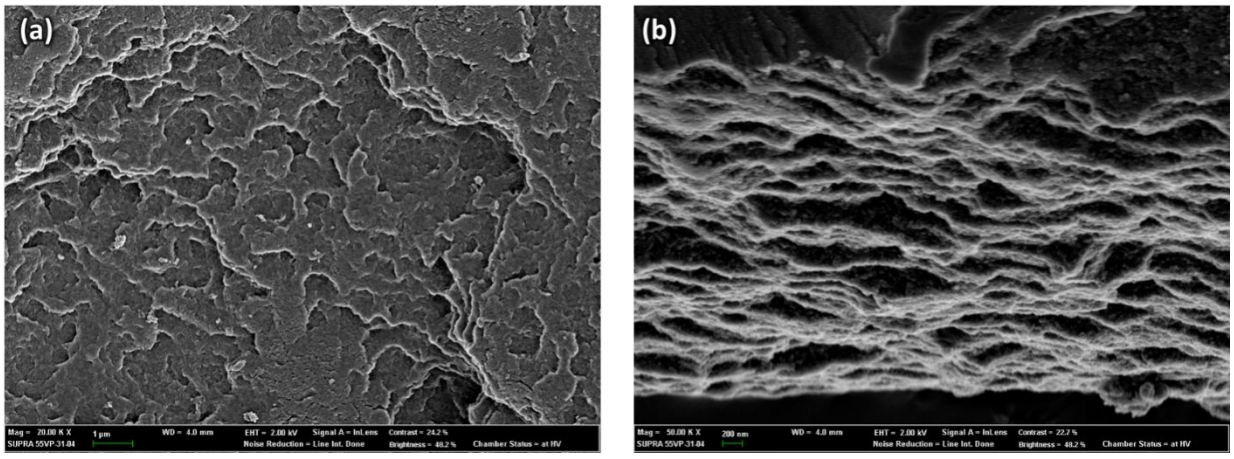


Figure S7. SEM images of the bucky paper obtained by vacuum filtration of Co-CANP dispersed in DMF: (a) top view (b) side view

Table S2. Chemical composition of co-compounded carbonaceous nanoplates obtained from elemental analysis

Sample	C (wt%)	H (wt%)	N (wt%)	Calculated O (wt%)
GL:DHB=9:1	65.2954	4.5532	0	30.1514
GL:DHB=8:2	65.0264	4.3315	0	30.6421
GL:DHB=7:3	66.7233	4.3895	0	28.8872
GL:DHB=6:4	73.6192	4.9716	0	21.4092
GL:DHB=5:5	67.3511	4.6912	0	27.9577
GL:DHB=4:6	66.9195	4.9317	0	28.1488

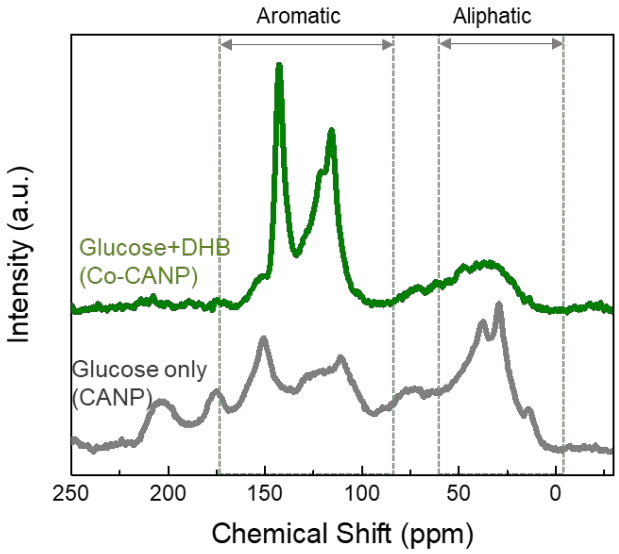


Figure S8. NMR data of Glucose only (CANP) and Glucose+DHB (Co-CANP) are shown. Co-CANP has more sharp peaks in the aromatic region compared to CANP, and more broad lower peaks in aliphatic region. It means Co-CANP has more graphitic structure than CANP.

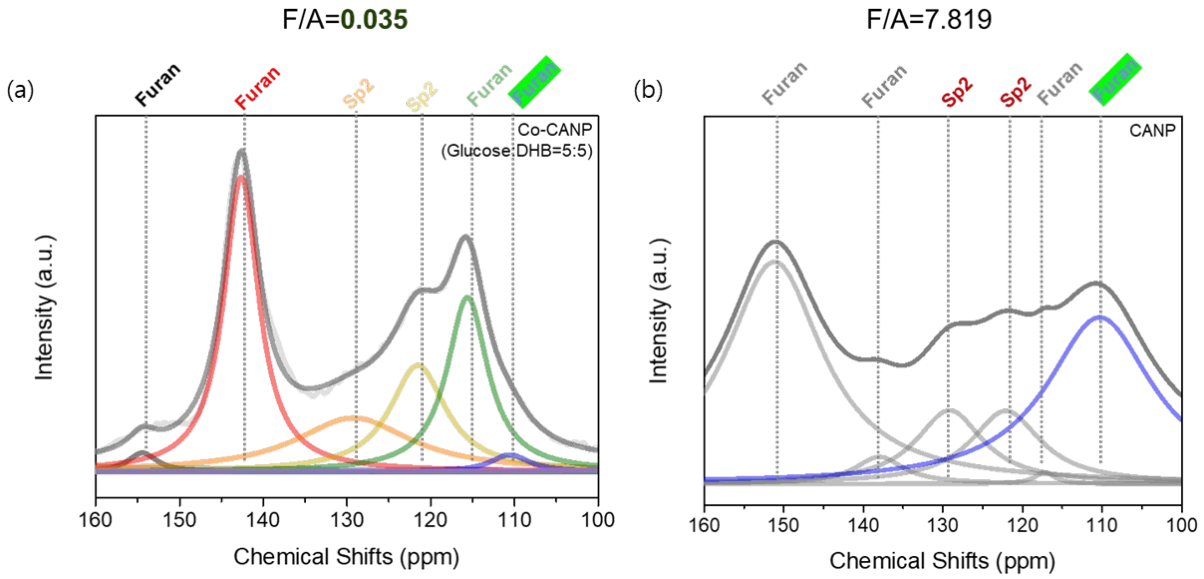


Figure S9. Deconvoluted NMR data of (a) Co-CANP and (b) CANP are shown. Furan to Arene ratio (F/A) are calculated through deconvoluted NMR data. The F/A ratio is 0.035 for co-CANP while it is 7.82 for CANP. This result suggests that Co-CANP has more arene structure than CANP.

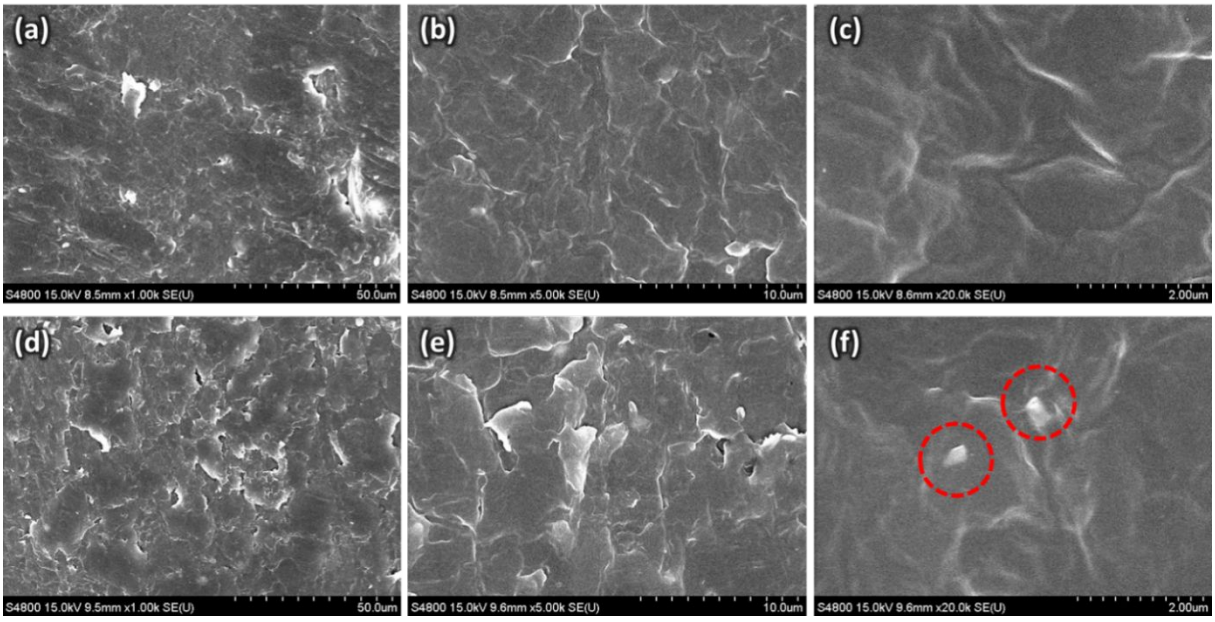


Figure S10. SEM images of S-SBR composites (a-c) composites without fillers (d-f) composites with 0.5 wt% of Co-CANPs as fillers. Red circles are indication of Co-CANPs.

Supporting Information References

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