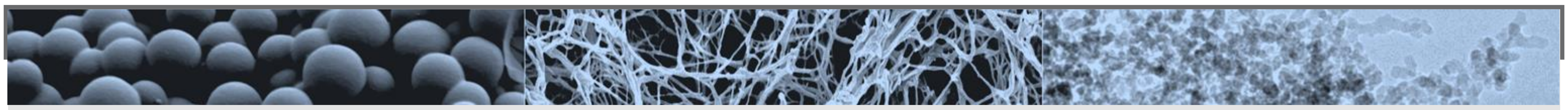
The effect of pulverization methods on microstructure of carbon aerogels for metal-sulfur batteries

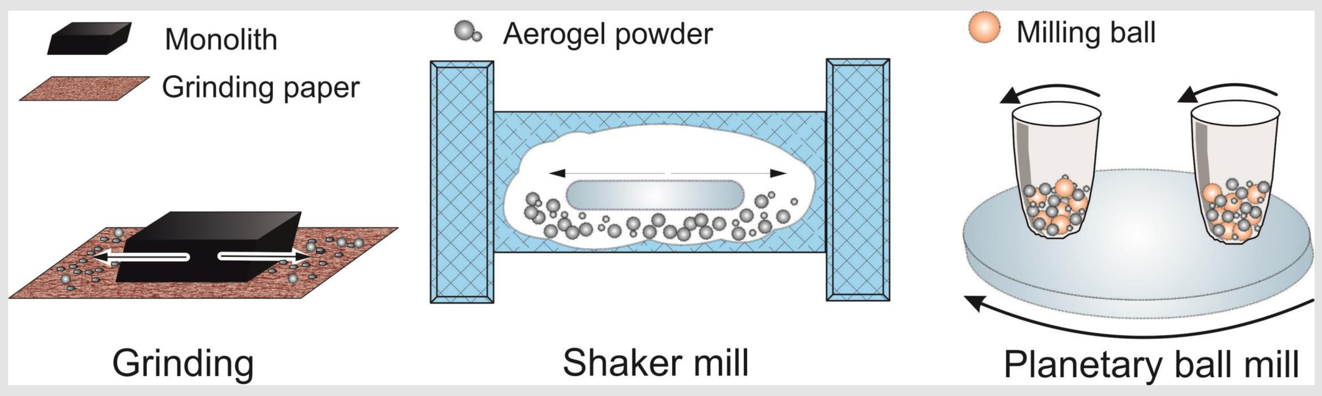


INTRODUCTION

Carbon aerogels are well known open porous solid materials usually obtained by carbonization of organic aerogels. Due to the adjustable microstructure, high surface area of up to 2000 m²/g and high pore volume of about 3 to 5 cm³/g, carbon aerogels are highly promising materials to be used as a well-defined porous matrix for sulfur to fabricate cathodes of metal-sulfur batteries. Encapsulating the sulfur as an active component into the micropores leads to a decreased polysulfide-shuttle-effect and higher cycle stability.

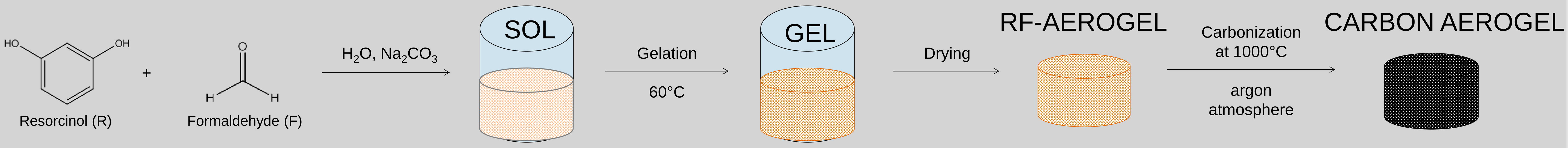
The deformation during pulverization of the adjusted porous structure has to be taken into account. The extent of the changes depends both on the dominant forces of the technique used and on the mechanical and structural properties of the initial monolithic samples.

In the present work, we show the influence of grinding, milling in shaker cryo mill and planetary ball mill on stiff, ductile and flexible carbon aerogels.



Techniques for pulverization with different main principles [1]

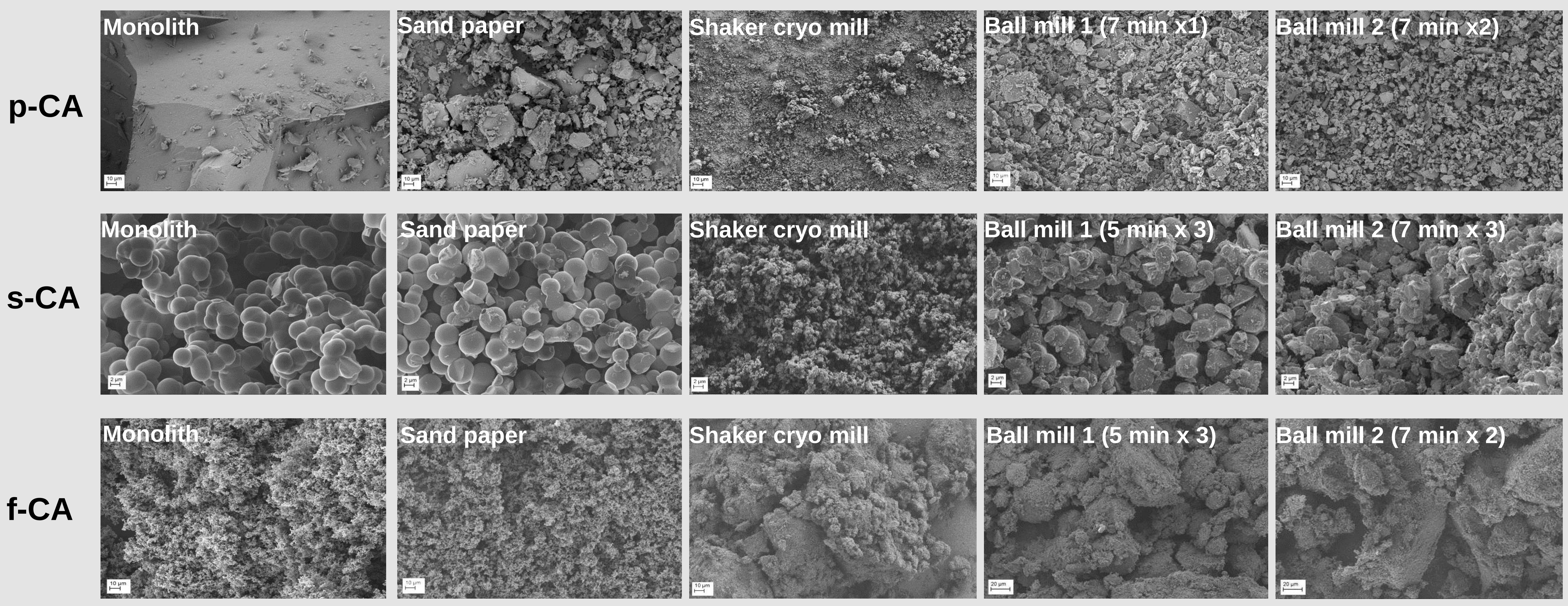
SYNTHESIS

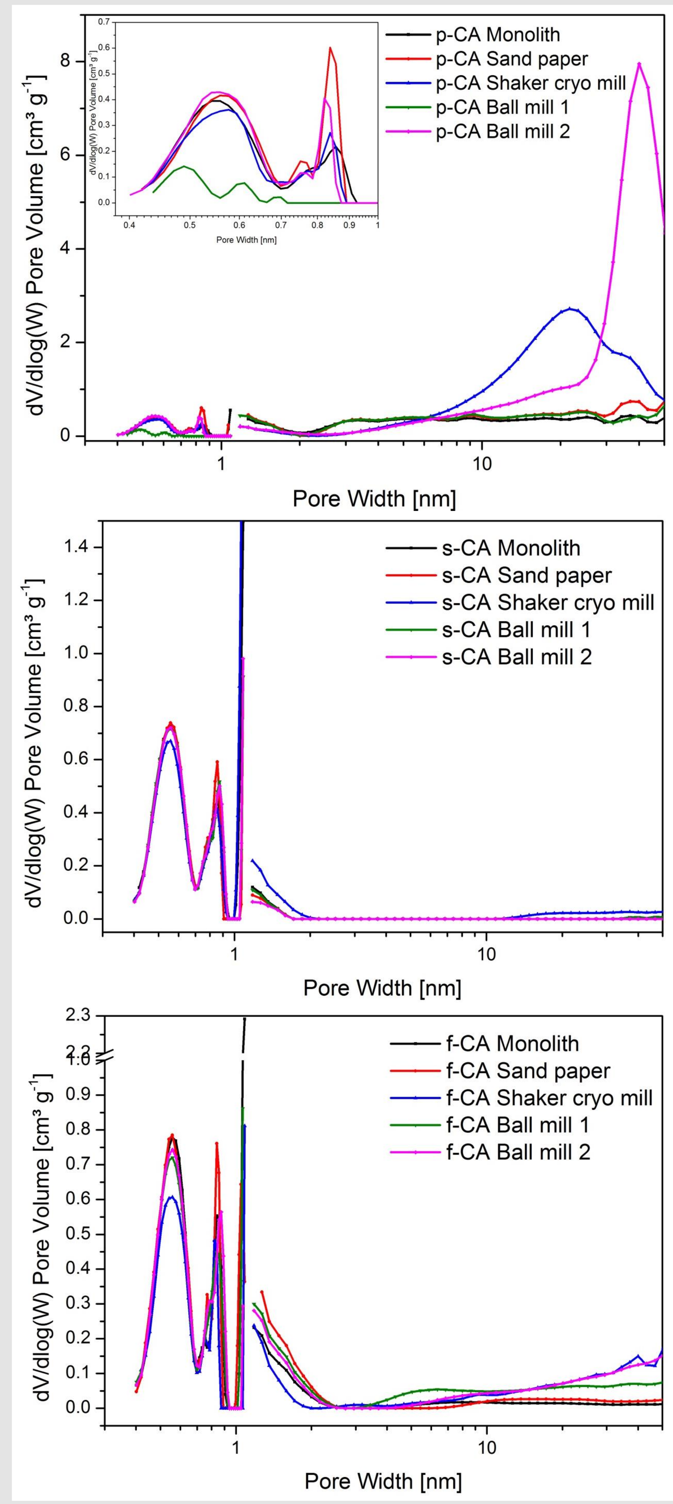


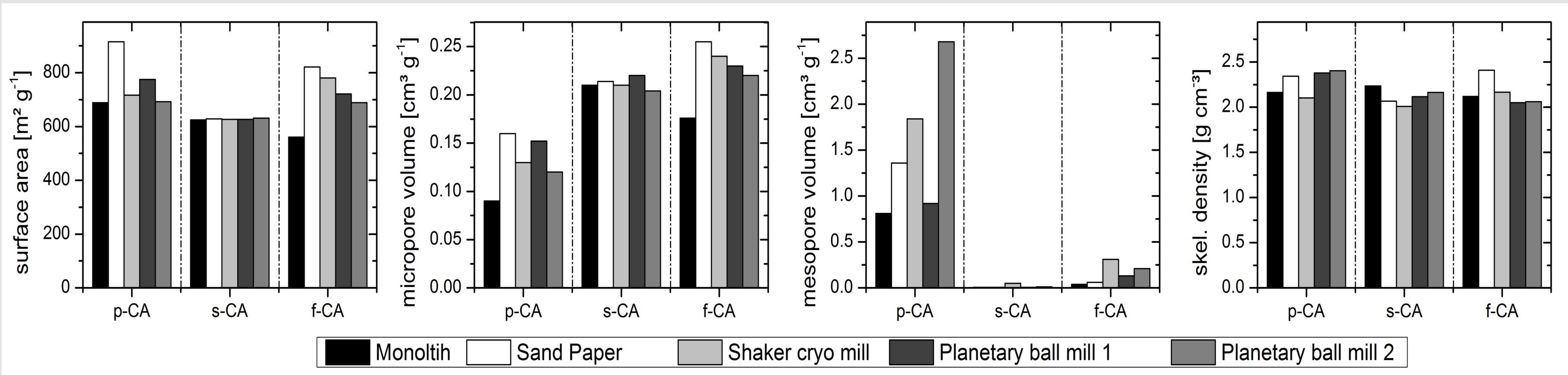
Synthesis parameters of the different types of carbon aerogels:

Type of aerogel	R:C molar ratio	R:W molar ratio	R:F molar ratio	pH of initial solution	Stirring time [min]	Gelation time [days]	Drying conditions	Carbonization conditions	Mechanical properties
p-CA	200	0.019	0.5	7.0	30	7	Super critical CO_2	1000 °C, 1 h, Ar	ductile
s-CA	1500	0.044	0.74	5.4-5.6	30	4	Ambient pressure at 80 °C	1000 °C, 1 h, Ar	stiff
f-CA	50	0.008	0.5	5.4-5.6	60	7	Super critical CO_2	1000 °C, 1 h, Ar	flexible

RESULTS & DISCUSSION

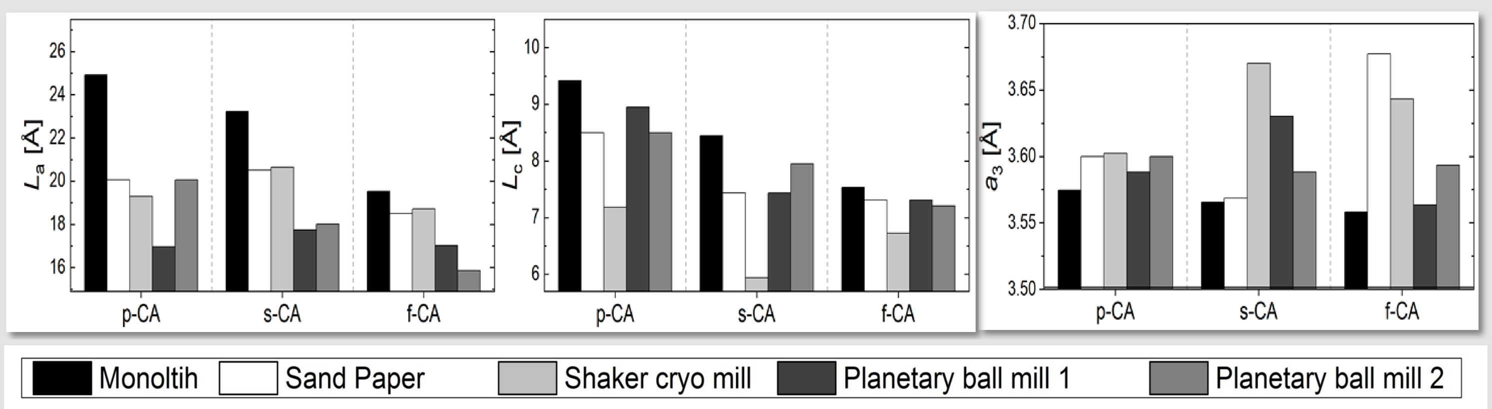






CONCLUSIONS

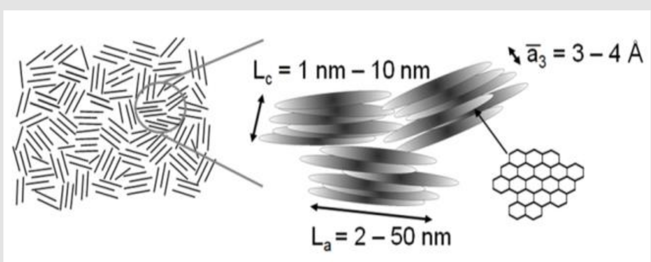
- Pulverization strongly influences the morphology of carbon aerogels.
- Effect of pulverization depends both on the mechanical properties of aerogels and on the applied method.
- The effect of milling and grinding is directly related to the amount of applied energy.
- Stiff carbon aerogel undergo the lowest structural changes.
- Ductile and flexible aerogels are sensitive to friction.
- After pulverization, the structure is less compact.
- The size of graphene layers and the number of stacks decrease during the pulverization treatment, while the distance between layers remains constant.
- Changes in structures upon pulverization lead to an increase in surface area and pore volume.
- Increased pore volume results in higher sulfur-content and capacities.



Properties of monolithic sample

	p-CA	s-CA	f-CA
Envelope density, g/cm³	0.29	0.32	0.04
Porosity, %	87	86	99
Electrical conductivity, S/m	265	350	5.5

L_a graphene layer size
L_c stack size
a_3 layer distance
(calculated with algorithm by Ruland and Smarsly)



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[1] Schwan M., Schettler J., Heinrich C., Badaczewski F., Smarsly B.M., Milow B., The effect of pulverization methods on the microstructure of stiff, ductile and flexible carbon aerogels, submitted

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