Graphitization as a way to stabilize textural characteristics of alumina under hydrothermal conditions

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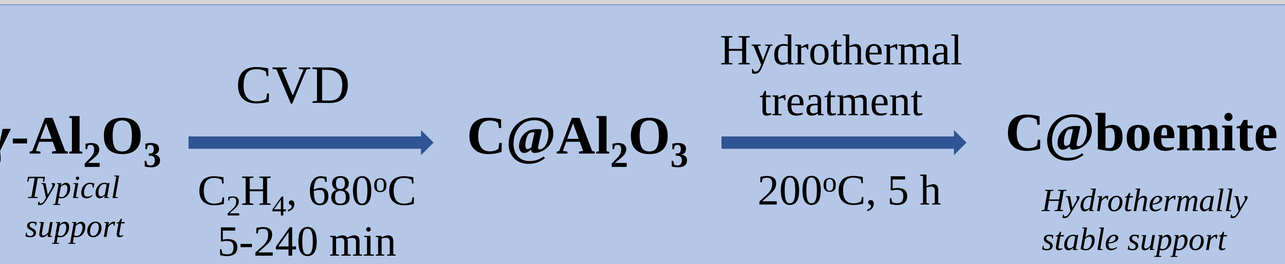
Introduction

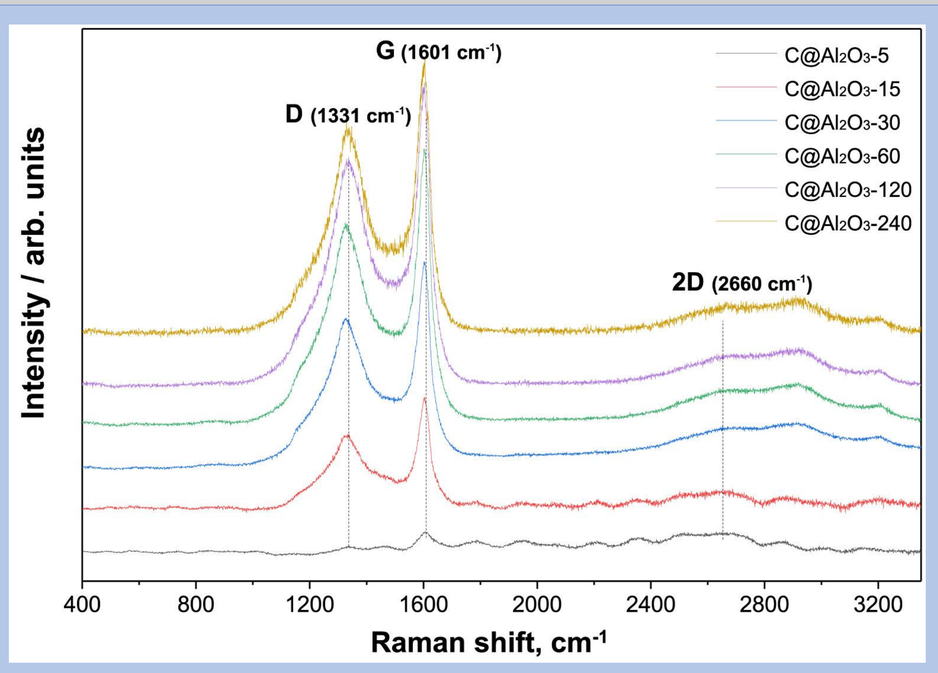
γ-Al_2O_3 is a widely used support for catalysts of various processes. The significant drawback of γ-Al_2O_3 is its instability in hydrothermal conditions, which might be essential for biomass refining processes. In the case of aqueous-phase processes, hydrothermal conditions result in transformation of γ-Al_2O_3 to boehmite, which is accompanied by degradation of the porous structure and leads to rapid catalyst deactivation.

The aim of this work is to propose the simple one-stage approach to protect γ-Al_2O_3 porous structure from collapse under hydrothermal conditions.

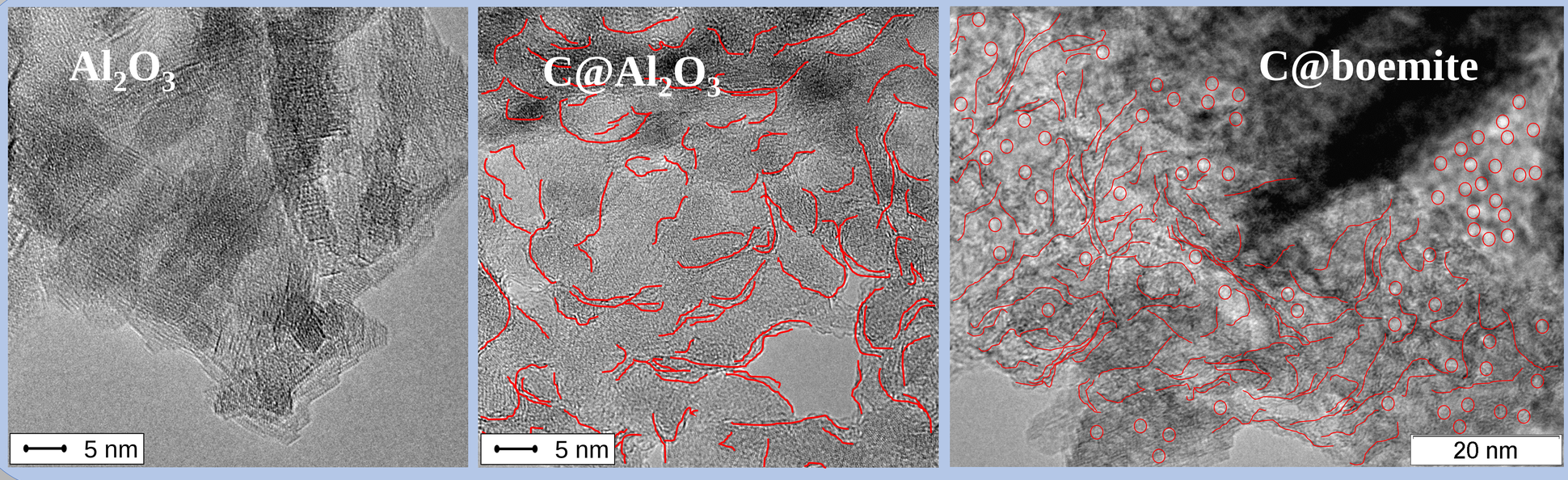


Sample	C content, wt%	Graphitization degree, %
C@Al_2O_3-5	1.4	6
C@Al_2O_3-15	9.1	36
C@Al_2O_3-30	11.2	45
C@Al_2O_3-60	15.5	62
C@Al_2O_3-120	21.8	87
C@Al_2O_3-240	25.5	102

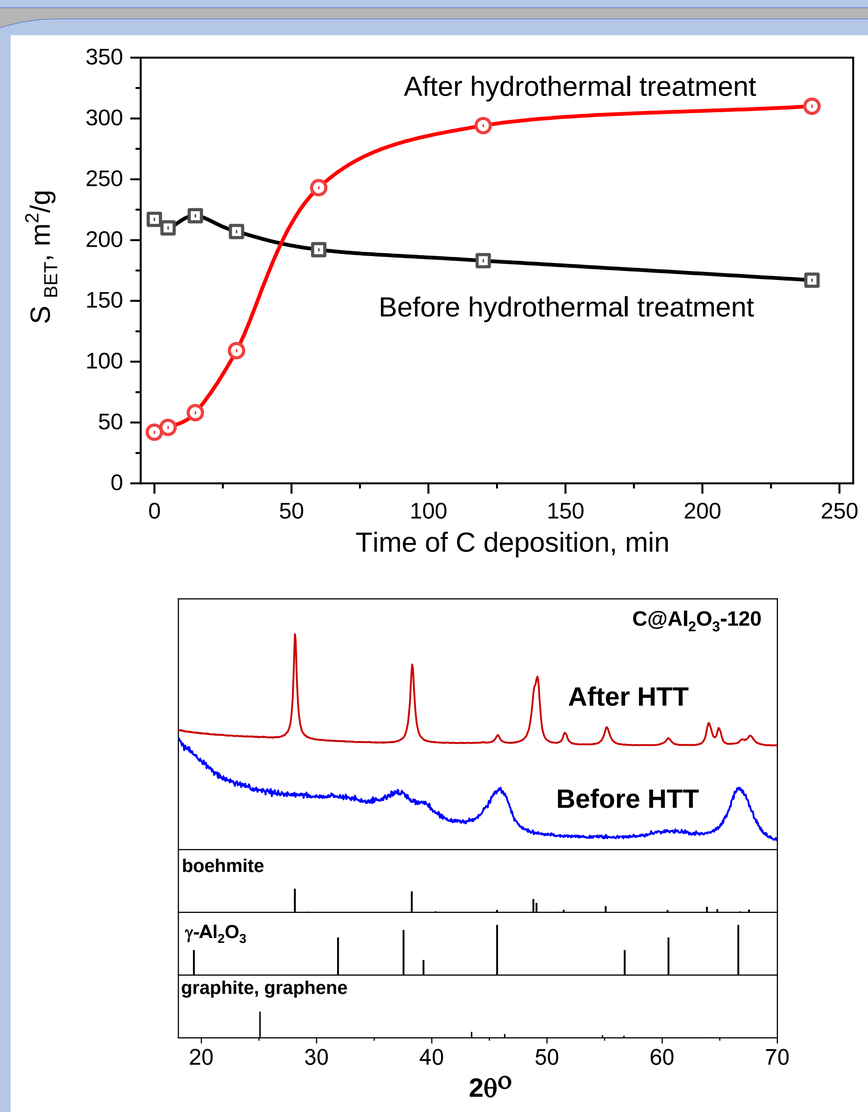
Treatment in C_2H_4 flow at 680°C for 120 min and more leads to the formation of a monolayer carbon coating on the alumina surface.



Carbon in C@Al_2O_3 samples, regardless of the graphitization time, is present in the form of nanocrystalline graphite with a graphene fragment size of less than 5 nm.



HRTEM data shows that the morphology of γ-Al_2O_3 consist of the mixture of polycrystalline lamellar particles up to 5 nm in size and needle-shaped particles with a length of 20 nm or more and does not change during graphitization.



- An increase in graphitization time leads to a slight decrease in BET surface area of C@Al_2O_3 samples.
- γ-Al_2O_3 transforms into boehmite during hydrothermal treatment (XRD data).
- Hydrothermal treatment leads to a decrease in the initial γ-Al_2O_3 surface area by 80%.
- A monolayer (or more) graphite coating of alumina under HTT contributes to the formation of a mesoporous C@boehmite composite with a high specific surface area similar to the initial material.
- An increase in the duration of HTT from 5 to 72 h does not lead to additional structural and textural changes, which indicates the stability of the formed C@boehmite composite.

Conclusion

Coating with carbon makes it possible to adapt γ-Al_2O_3 to hydrothermal conditions, which makes C@Al_2O_3 composites a promising support for catalysts of various aqueous-phase reactions.

References

M.A. Kazakova, A.G. Selyutin, M.V. Parfenov, A.V. Ishchenko, M.O. Kazakov, Micropor. Mesopor. Mat, 341 (2022) 112038.

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