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# Helium-3 gas self-diffusion in a nematically ordered aerogel at low temperatures: Enhanced role of adsorption

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## Abstract

© 2017 the Owner Societies. We performed 3 He gas diffusion measurements for the first time in a highly porous ordered Al 2 O 3 aerogel sample at a temperature of 4.2 K using a nuclear magnetic resonance field gradient technique. A strong influence of 3 He adsorption in the aerogel on self-diffusion is observed. The classical consideration of adsorptive gas diffusion in mesopores leads to anomalously high tortuosity factors. The application of a more sophisticated model than the simple combination of empirical two-phase diffusion and the Knudsen gas diffusion models is required to explain our results. Anisotropic properties of the aerogel are not reflected in the observed gas diffusion even at low gas densities where the anisotropic Knudsen regime of diffusion is expected. The observed gas densification indicates the influence of the aerogel attractive potential on the molecular dynamics, which probably explains the reduced diffusion process. Perhaps this behavior is common for any adsorptive gases in nanopores.

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## References

[1] J. Kärger R. Valiullin Chem. Soc. Rev. 2013 42 4172
[2] N. Zhelev M. Reichl T. S. Abhilash E. N. Smith K. Nguyen E. Mueller J. M. Parpia Nat. Commun. 2016 7 12975
[3] V. V. Dmitriev A. A. Senin A. A. Soldatov A. N. Yudin Phys. Rev. Lett. 2015 115 165304
[4] E. Collin S. Triqueneaux Y. M. Bunkov H. Godfrin Phys. Rev. B: Condens. Matter Mater. Phys. 2009 80 094422
[5] D. Candela N. Kalechofsky J. Low Temp. Phys. 1998 113 351
[6] J. A. Sauls Y. M. Bunkov E. Collin H. Godfrin P. Sharma Phys. Rev. B: Condens. Matter Mater. Phys. 2005 72 024507
[7] V. V. Dmitriev L. A. Melnikovsky A. A. Senin A. A. Soldatov A. N. Yudin JETP Lett. 2015 101 808
[8] G. Tastevin P.-J. Nacher J. Chem. Phys. 2005 123 064506
[9] R. Valiullin P. Kortunov J. Kärger V. Timoshenko J. Phys. Chem. B 2005 109 5746
[10] R. Mueller S. Zhang M. Klink M. Baumer S. Vasenkov Phys. Chem. Chem. Phys. 2015 17 27481
[11] J. A. Lee A. M. Mounce S. Oh A. M. Zimmerman W. P. Halperin Phys. Rev. B: Condens. Matter Mater. Phys. 2014 90 174501
[12] S. K. Bhatia O. Jepps D. Nicholson J. Chem. Phys. 2004 120 4472
[13] M. R. Bonilla S. K. Bhatia J. Membr. Sci. 2011 382 339
[14] S. K. Bhatia D. Nicholson Chem. Eng. Sci. 2011 66 284
[15] V. E. Asadchikov R. S. Askhadullin V. V. Volkov V. V. Dmitriev N. K. Kitaeva P. N. Martynov A. A. Osipov A. A. Senin A. A. Soldatov D. I. Chekrygina A. N. Yudin JETP Lett. 2015 101 556

[16] E. Alakshin R. Gazizulin A. Klochkov V. Kuzmin A. Sabitova T. Safin M. Tagirov Magn. Reson. Solids 2013 15 13104
[17] A. Abragam, The Principles of Nuclear Magnetism, Oxford University Press, Oxford, 1961
[18] E. M. Alakshin M. Y. Zakharov A. V. Klochkov V. V. Kuzmin K. R. Safiullin A. A. Stanislavovas M. S. Tagirov JETP Lett. 2016 104 315
[19] J. G. Daunt C. Z. Rosen J. Low Temp. Phys. 1970 3 89
[20] M. Bretz J. G. Dash D. C. Hickernell E. O. McLean O. E. Vilches Phys. Rev. A: At., Mol., Opt. Phys. 1973 8 1589
[21] C. P. Chen S. Mehta E. A. Hoefling S. Zelakiewicz F. M. Gasparini J. Low Temp. Phys. 1996 102 31
[22] J. G. Daunt and E. Lerner, Monolayer and Submonolayer helium films, Springer, 1973
[23] A. V. Klochkov V. V. Kuz'min K. R. Safiullin M. S. Tagirov D. A. Tayurskii N. Mulders JETP Lett. 2008 88 823
[24] K. Luszczynski R. E. Norberg J. E. Opfer Phys. Rev. 1962 128 186
[25] B. P. Cowan M. G. Richards A. L. Thomson W. J. Mullin Phys. Rev. Lett. 1977 38 165
[26] B. Cowan M. Fardis T. Crane L. Abou-El-Nasr Phys. B 1990 165-166 707
[27] R. Kimmich, Principles of Soft-Matter Dynamics: Basic Theories, Non-invasive Methods, Mesoscopic Aspects, Springer, Netherlands, 2012
[28] C. P. Lusher M. F. Secca M. G. Richards J. Low Temp. Phys. 1988 72 25
[29] M. Sinvani M. W. Cole D. L. Goodstein Phys. Rev. Lett. 1983 51 188
[30] M. Dvoyashkin A. Khokhlov S. Naumov R. Valiullin Microporous Mesoporous Mater. 2009 125 58
[31] N. S. Sullivan J. Low Temp. Phys. 1976 22 313
[32] D. R. Swanson D. Candela D. O. Edwards J. Low Temp. Phys. 1988 72 213
[33] N. Setoyama K. Kaneko Adsorption 1995 1 165
[34] N. Setoyama K. Kaneko F. Rodriguez-Reinoso J. Phys. Chem. 1996 100 10331
[35] A. W. Thornton A. Ahmed S. K. Kannam B. Todd M. Majumder A. J. Hill J. Membr. Sci. 2015 485 1
[36] C. P. Lusher M. F. Secca M. G. Richards J. Low Temp. Phys. 1988 72 71