Keynote

📅 Thu. Jul 31, 2025 9:15 AM - 10:10 AM JST | Thu. Jul 31, 2025 12:15 AM - 1:10 AM UTC 🏛 Room A & B(2F The SalonThe Grand Ballroom)

[3S01-02] Plenary & Keynote 3

Chair:Tomohiko Okada(Shinshu University)

9:15 AM - 9:45 AM JST | 12:15 AM - 12:45 AM UTC

[3S01]

[Plenary] Materials Energy Science on Carbon Nanostructures

*Katsumi Kaneko[1] (1. Shinshu University (Japan))

9:45 AM - 10:10 AM JST | 12:45 AM - 1:10 AM UTC

[3S02]

[Keynote] Size and surface design of titania nanoparticles

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Materials Energy Science on Carbon Nanostructures

Ancient people had environmentally friendly lives with well-organized cyclic systems in the Jomon Era (14,000 BC to 1,000 BC) in Japan. The present human society must gain the enough sustainability with innovative energy materials science. We have challenged to innovate new nanostructured carbon materials for energy storage and environmentally friendly separation.

Development of better supercapacitors has been requested on the basis of fundamental understanding[1]. The structure of ionic liquid, EMI-TFSI, in 0.7 nm pores of carbon was studied with HRMC simulation-aided X-ray scattering. We evidenced the partial breaking of Coulombic law for the assembly structure of IL ions[2]. The ambient pressure storage of high-density methane in nanoporous carbon particles coated with graphene of the valve function. The nanographene valves open at 473 K and close at ambient temperature. The stored methane of large amount can be stably stored for two weeks at least[3]. We prepared the SWCNT ropes which have the gravimetric energy density (GED) of up to 2.1 MJ kg^{-1} exceeding by over four orders of magnitude that of mechanical steel springs and by a factor of 3 that of advanced LIBs in addition to the low temperature stability[4].

The theoretical study showed that nanowindows on graphene has a high potential for separation of oxygen from nitrogen[5]. Then, we need to develop the new membrane for oxygen and nitrogen using graphene, which can contribute to huge reduction of CO_2 emissions. Ultrafast-permeable graphene-wrapped zeolite crystal membranes which give an excellent separation ability, as evidenced by marked upward-deviation from the upper bound of Robeson plot. The graphene-wrapped zeolite has the subnanoscale channels of < 0.4 nm in width between graphene and crystal faces, which induce high selectivity. The permeability of H_2 is 5.8×10^6 barrers and a single gas selectivity of H_2 against CH_4 is 245[6]. This graphene-wrapped zeolite membrane is quite efficient for oxygen and nitrogen separation[7]. Graphene-wrapped zeolite membranes are prepared from zeolite and unstable graphene oxide (GO) colloids. We evidenced the presence of three GO states with the ripening time; an intrinsic graphene oxide (iGO) in the early stage of the ripening process gave the graphene-wrapped zeolite membrane the best separation performance[8].

1) M. Salanne et al., *Nature Energy*,**1**, Article number: 16070 (2016).
2) R. Futamura et al., *Nature Mater*. **16**, 1163-1273 (2017).
3) S. Wang et al., *Nature Energy.* In press.
4) S. Utsumi et al. *Nature Nanotech*. **19**, 1007-1015 (2024).
5) F. Vallejos-Burgos, F.X.Coudert, K. Kaneko, *Nature Comm*.**9**, 1812 (2018).
6) R. Kukobat.et al, *Sci. Adv*. **8**, eabl3521 (1-11) (2022).
7) H. Otsuka et al., *Nature Comm.* **15**, 1708(1-10) (2024).
8) H. Otsuka et al., in preparation

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Size and surface design of titania nanoparticles

Hybridization of functional particles with other components has been examined for several objectives including catalysts' design.[1,2] The immobilization of titania particles with solid supports such as clays has been reported.[1,2] For some application, coating of titania particle with silica has been examined.[3] On the other hand, preparation of nanoparticles in nanospaces is a way to obtain well-defined nanoparticles without aggregation/fusion. The preparation of well-defined semiconductor nanoparticles using mesoporous silica as template has been reported.[4-6] The preparation is based on the infiltration of molecular precursor into the pore and the subsequent crystallization in the pore. Anatase nanoparticles with the diameter similar to the pore size of the template (cylindrical mesopore of SBA-15 with the pore diameter of 8 nm) were prepared by the infiltration of titanium alkoxide and the subsequent in-situ crystallization in the mesopore by the calcination.[4] Rutile nanoparticles were obtained by the infiltration of titanium alkoxide and the subsequent crystallization by the reaction with HCl vapor at room temperature.[5] In addition, porous polymer film was utilized to design anatase nanoparticles.[6].

References [1] Wijitwongwan, R. P. et al., *Dalton Trans.*, 2024, **53**, 6144 [2] Ruiz-Hitzky, E. et al., *Beilstein J. Nanotech.*, 2019, **10**, 1140, Deepracha, S. et al., *Applied Clay Sci.,* 2019, **169,** 129, Deepracha, S. et al., *Appl. Catal. B: Environ.*, 2021, 119705, Deepracha, S. et al., *Separation Purification Tech.,* 2021*,* **262**, 118307, Vejchakul, K.F., Ogawa, M., *Top. Catal.* 2023, **66,** 1649. [3] Cheepborisutikul, S.J. Ogawa M. *Inorg. Chem.*, 2021, **60**, 6201. *ibid.*, 2023, **62**, 12166. [4] Vibulyaseak, K.G. et al., *Chem. Commun.*, 2019, **55**, 8442. Paengjun, N.K. et al., *ACS Applied Nano Mater.,* 2023, **5***,* 18004 (2023). [5] Vibulyaseak, K.G., et al., *Inorg. Chem.* 2020, **59**, 7934. Paengjun, N.K. et al., *Sci. Rep.* 2021, **11**, 1. [6] Vejchakul, K.F., Ogawa, M., *ACS Applied Nano Mater.,* 2025, **8**, 3402.