

## One-pot synthesis of multi-metallic alloy nanoparticle supported carbon nanotube composite materials using ionic liquid

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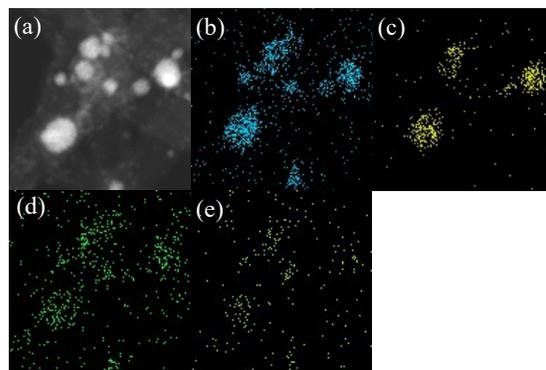
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Many methods for nanoparticle preparation using ionic liquids (ILs) have been reported.<sup>1</sup> In this study, based on our accumulated knowledge through our previous research on nanoparticle preparation in IL as both the reaction medium and stabilizing agent,<sup>2</sup> we established a simple one-pot method in which metal precursors, IL, and carbon supports are heated and stirred in an airtight vessel, enabling direct formation of multi-metallic alloy nanoparticle supported multi-walled carbon nanotube (MWCNT) composite materials. The IL used was *N,N,N*-trimethyl-*N*-propylammonium bis(trifluoromethanesulfonyl)amide ([N<sub>1113</sub>][Tf<sub>2</sub>N]). Acetylacetonate complexes of Pt, Pd, Ru, Rh, Ni, and Ag were employed as metal precursors, and the one-pot process was conducted under a nitrogen atmosphere with stepwise heating up to 573 K.

Figure 1 shows HAADF-STEM and EDS mapping images of one of the typical specimens prepared in the IL with four metal precursors. The structural and compositional analyses revealed the formation of medium-entropy alloy nanoparticles composed of Pt, Pd, Ru, and Rh, exhibiting an average diameter of  $3.6 \pm 1.6$  nm. Elemental mapping and electronic structure analysis corroborated homogeneous metal distribution in the nanoparticles at the atomic scale. Not just a reaction medium and stabilizing agent, the IL also acts like a glue, and the resulting nanoparticles were spontaneously anchored onto the MWCNT surface. The results obtained in this investigation strongly suggest that one-pot synthesis of high-entropy alloy nanoparticles supported MWCNT composite materials is possible. We are currently conducting this research and will report the results in our presentation.



**Fig. 1** (a) HAADF-STEM image and (b-e) EDS mapping of the PtPdRuRh alloy nanoparticle supported MWCNTs prepared with the one-pot method. Elements are (b) Pt, (c) Pd, (d) Ru, and (e) Rh.

### References

1. Torimoto, T.; Tsuda, T.; Okazaki, K.; Kuwabata, S. *Adv. Mater.* **2010**, *22*, 1196 and references therein.
2. Yao, Y.; Tsuda, T.; Torimoto, T.; Kuwabata, S. *Chem. Rec.* **2023**, e202200274 and references therein.



Yudai KOJIMA is a second-year master's course student in the Department of Materials Science, Graduate School of Science and Engineering, Chiba University. I received my Bachelor's degree from the Faculty of Engineering, Chiba University in 2024. My research interest is the fabrication of nanomaterials using ILs for electrochemical technologies.