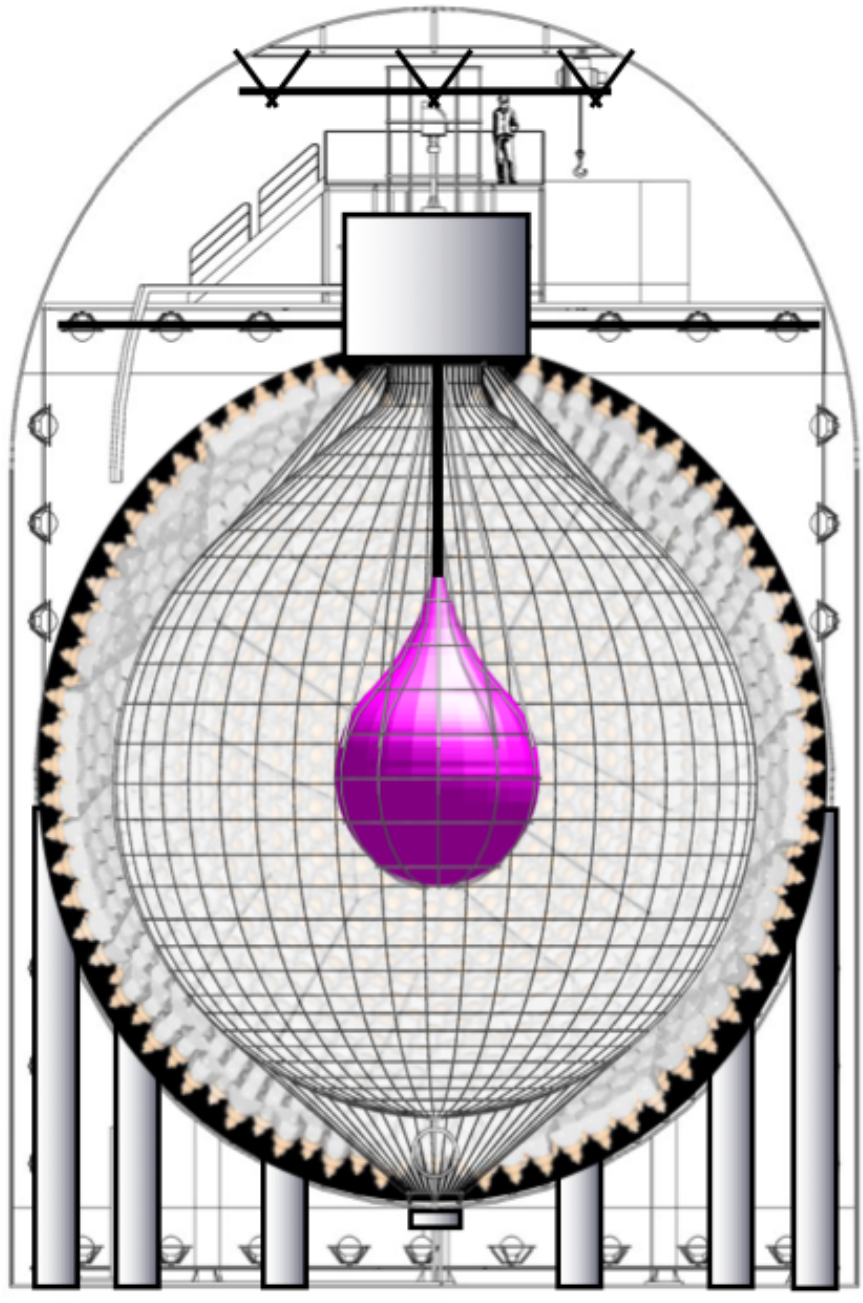


Formulation of Copper-Ion-Exchanged Zeolites for Xenon Enrichment Collection

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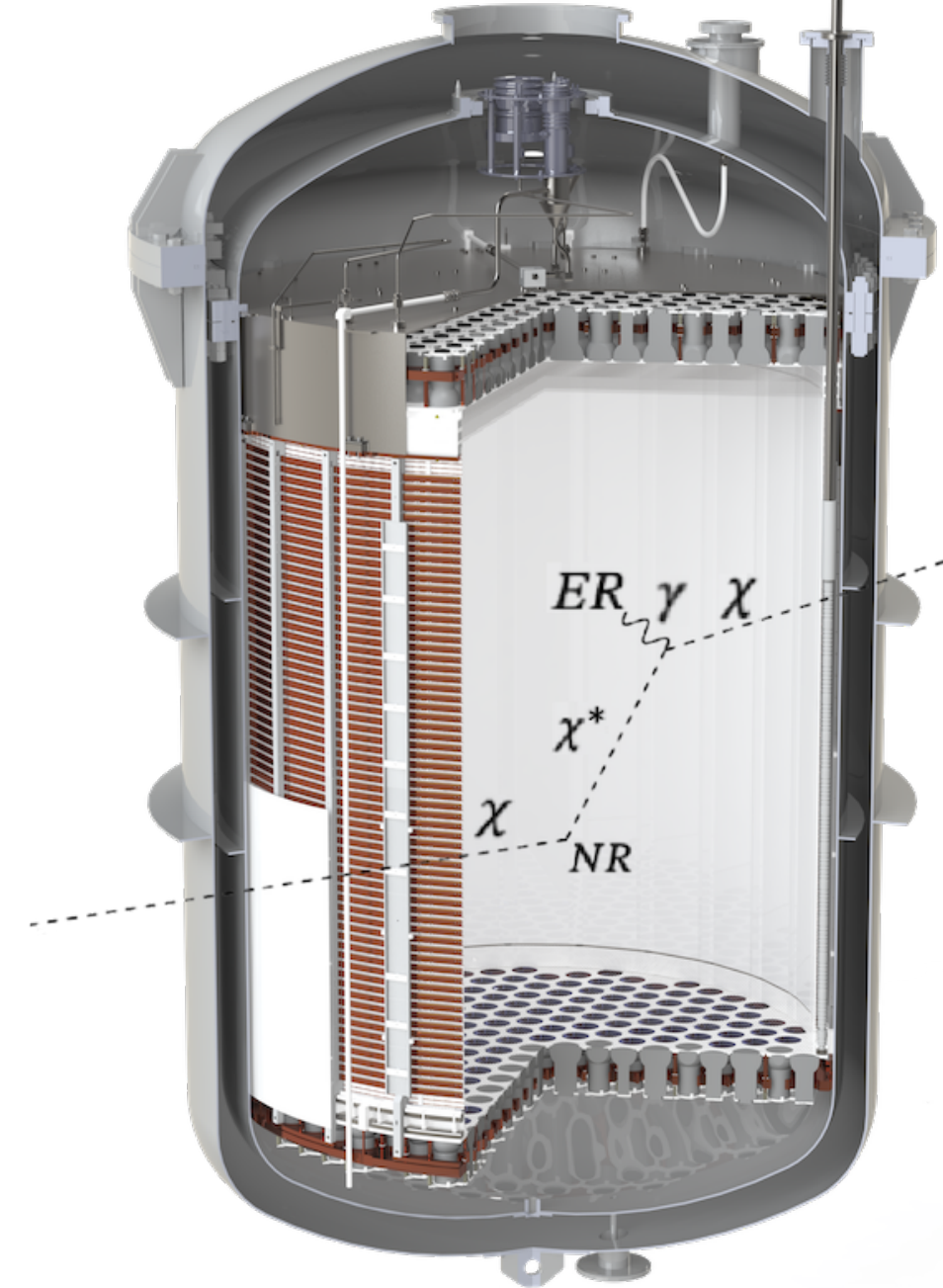
Xenon and extremely rare events experiments

$0\nu\beta\beta$ Decay Search



1 ton Xenon (90% enriched)[1]

Direct search for Dark Matter



8.5 ton Xenon[2]

- Current leading underground rare event search experiments ($0\nu\beta\beta$ Decay Search and Direct search for Dark Matter) using large amount of xenon.
- If we were to design experiments for 10 times the sensitivity of the current measurement, future experiments would require several hundred tons of xenon.
- Annual xenon production is estimated to be less than 100 tons, and since it is used in various industries, it is considered difficult to obtain in large quantities.

[1] https://www.awa.tohoku.ac.jp/rcns/Research_profiles.html

[2] E. Aprile et.al., arXiv:2608.15149

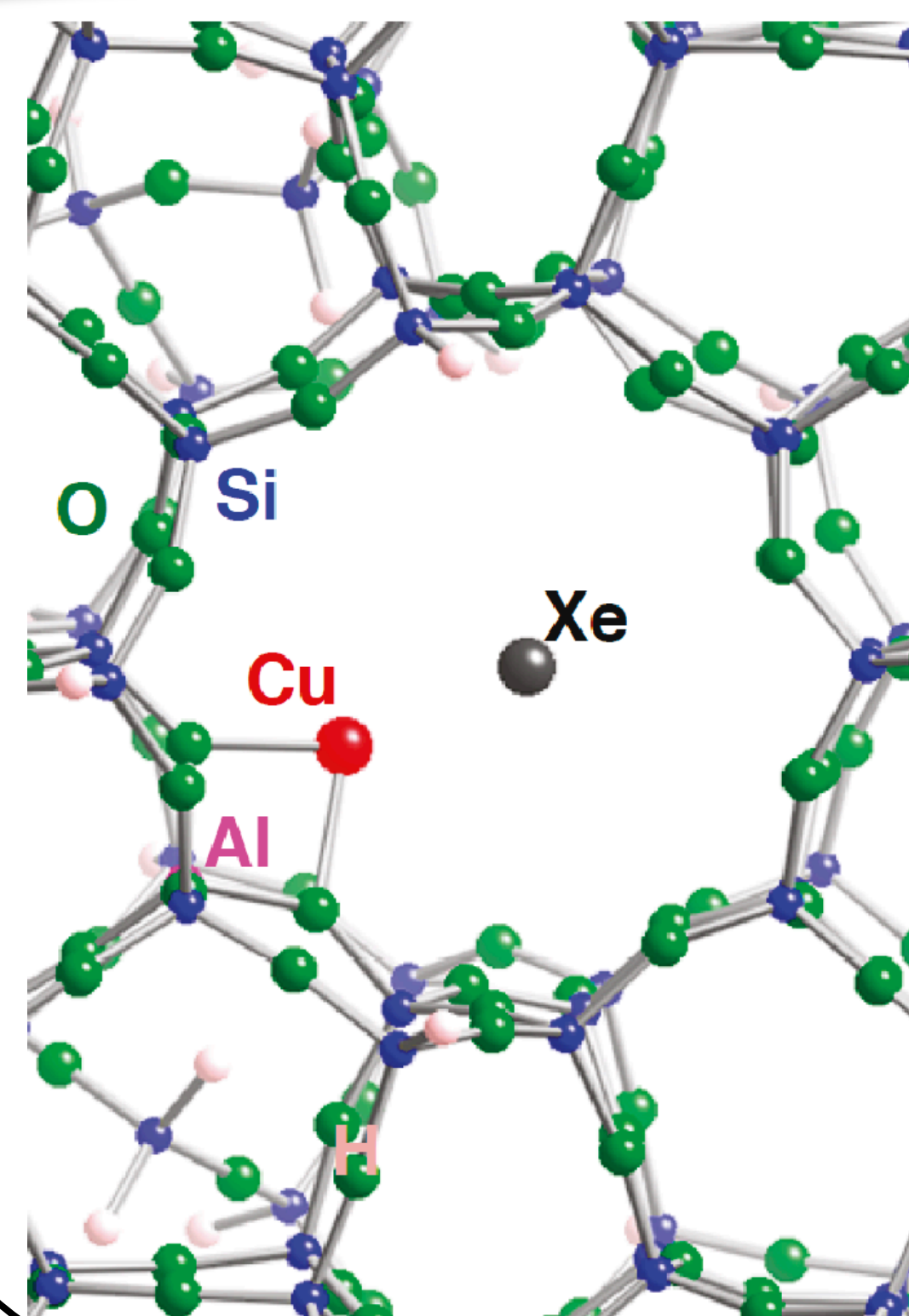
Zeolites

- Zeolites are a type of aluminosilicate with a three-dimensional framework structure
- Various parent zeolites exist, distinguished by differences in their Si/Al ratios and framework structures.
- It is classified as a so-called powder.
- Silver-ion-exchange zeolites are being studied for radon removal[3][4].

[3] H. Ogawa et al., Prog. Theor. Exp. Phys. 2025 023H04

[4] T. Sone et al., Prog. Theor. Exp. Phys. 2025 013H01

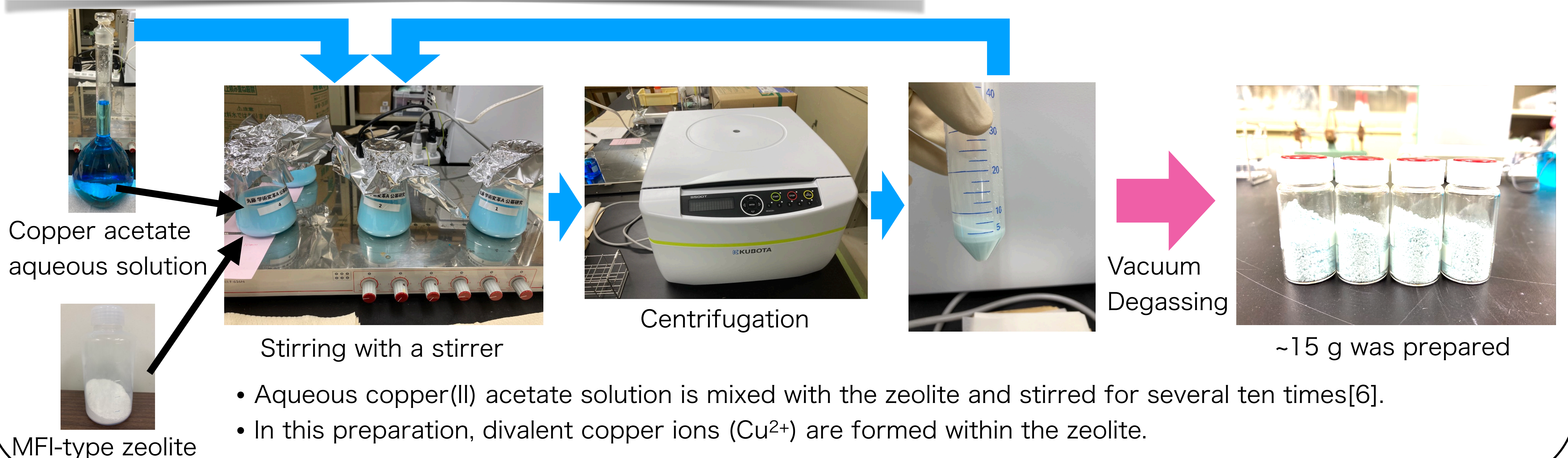
Copper-Ion-Exchanged Zeolites



- It is prepared by introducing copper ions into the parent zeolite via ion exchange.
- A material with **unique adsorption capabilities that are impossible for copper ions alone.**
- A monovalent copper (Cu^+) ion-exchanged zeolite based on MFI-type zeolite ($\text{Si}/\text{Al} = 14.5$) **adsorbs xenon even at room temperature**[5].
- Research on recovering xenon adsorbed onto copper-ion-exchange zeolites has not yet progressed.
- We aim to recover trace amounts of xenon present in the air using copper-ion-exchanged zeolite.

[5] Hiroe Torigoe et al., J. Phys. Chem. Lett. 2010, 1, 2642-2650

Formulation of Copper-Ion-Exchanged Zeolites



[6] A.Itadani et al., J. Phys. Chem. C, 111, 12011-12023 (2007)

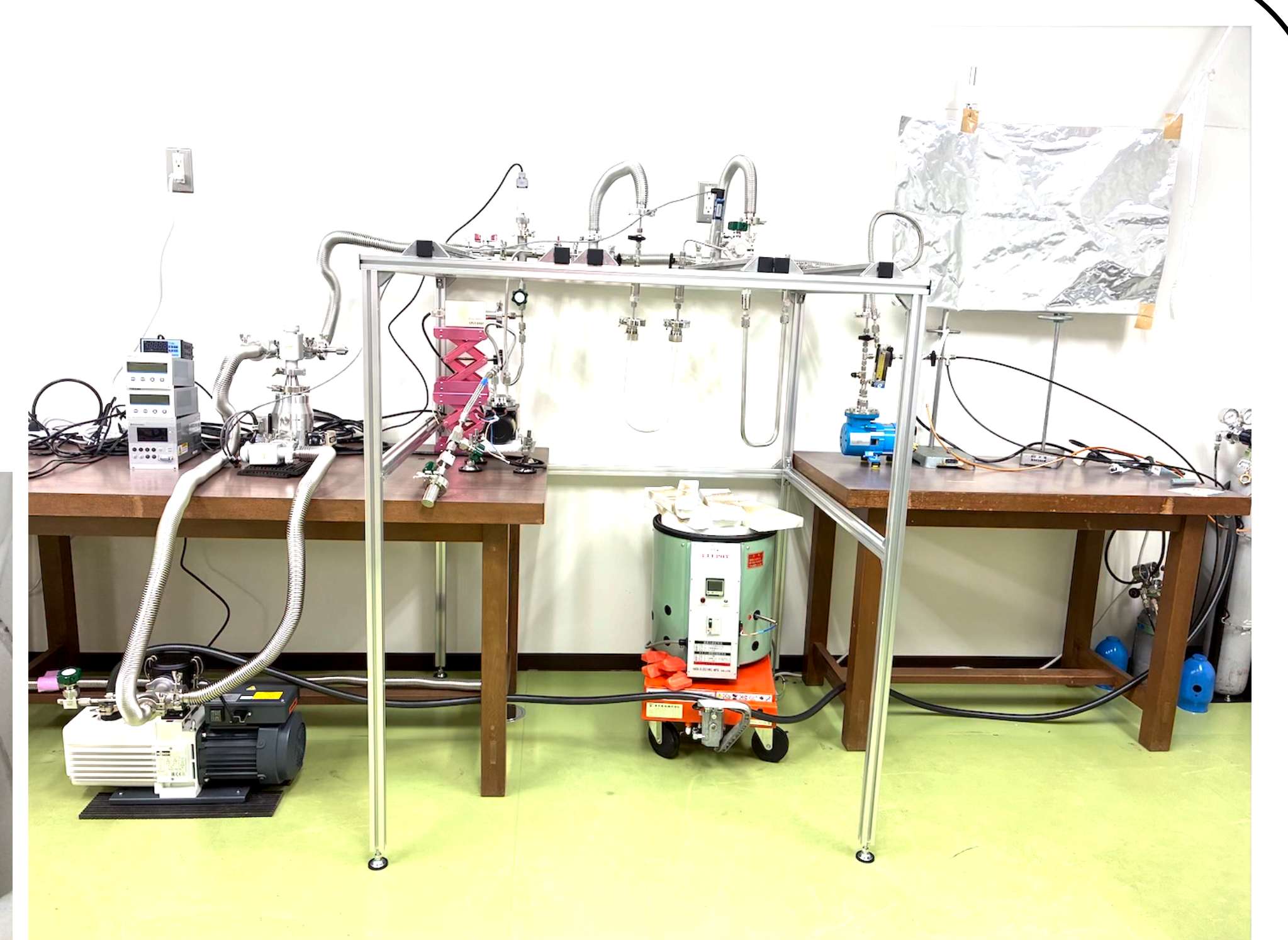
Activation of Copper-Ion-Exchanged Zeolites

- Since divalent copper ion-exchanged zeolite (Light blue) does not readily adsorb gas, it is necessary to heat it to convert it into monovalent copper ion-exchanged zeolite (White).
- The estimated heating time required for copper ion-exchanged zeolite is several hours at approximately 873 K.
- We plan to test xenon gas recovery using the gas adsorption/desorption apparatus.



Cu^{2+} zeolite

Cu^+ zeolite



Gas adsorption/desorption apparatus