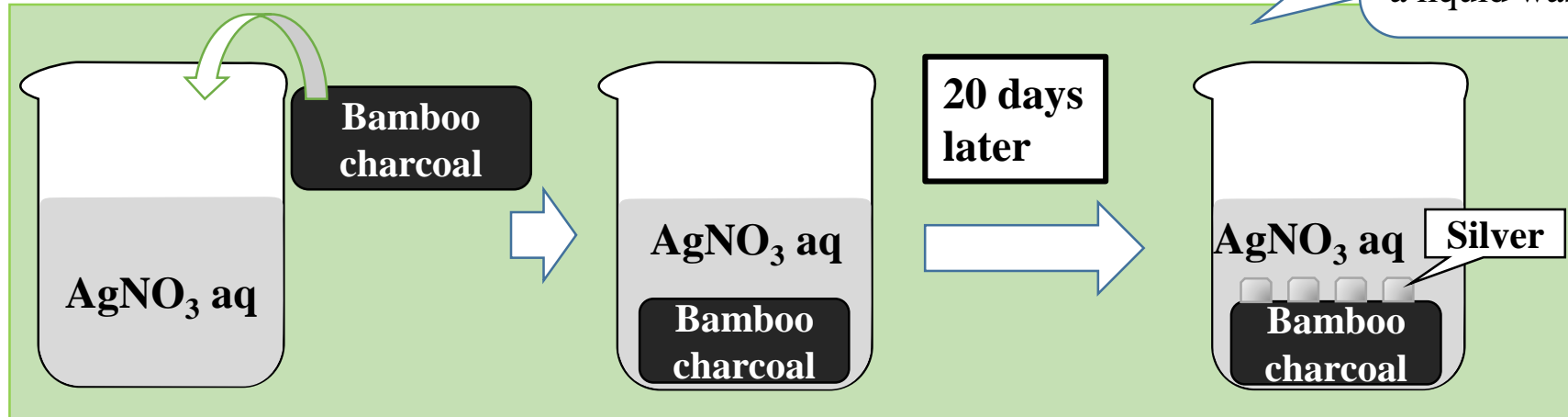


Chemistry

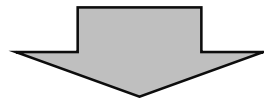
Reducibility of Silver ions by the Charcoal: Regarding Mechanisms, Art, and Liquid Waste Management

Background

According to the previous research¹⁾,



However, the cause of this reaction was not clarified.



We conducted a replication experiment.

Result: Silver deposited from a Bamboo charcoal.



[Purpose of research]

Fig.1 Deposit silver from a bamboo charcoal

**In this research,
we elucidated the cause of silver deposition from bamboo charcoal.**

Experiment

At first, we conducted these three experiments to understand reaction condition.

1. Is silver deposited by porous materials other than bamboo charcoals?

Diatomaceous soil, Silica gel and Zeolite were soaked in AgNO_3 aqueous solution. After that, we checked whether silver deposit or not.

➔ **Result:** Silver did not deposit from porous materials other than charcoals.

2. Do the charcoals other than bamboo charcoal deposit silver?

Cedar charcoal, Bincho charcoal*¹ and Activated charcoal were soaked in AgNO_3 aqueous solution. After that, we checked whether silver deposit or not.

➔ **Result:** Silver also deposited from the charcoals other than bamboo charcoals.

3. Does the mass of deposited silver change when the mass of charcoal is changed?

We measured the mass of deposited silver from the bincho charcoal which mass is 1.0 g ~ 4.0 g, 0.5 g and 8.0 g by using the Mohr method.

➔ **Result:** There was a positive correlation between the amount of deposited silver and the mass of charcoals.

Discussion

Throughout these three experiments, we understood that ...

The reducing agent which is contained in charcoals deposits silver.

This reducing agent is common to all kinds of charcoals

What is a common thing among charcoals?



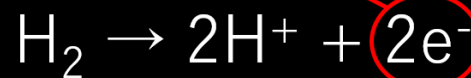
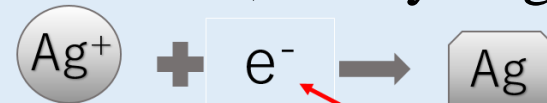
It is carbonization

A lot of hydrogen is generated during charcoals are made by being carbonized^{2), 3)}.

Hypothesis

Hydrogen produced during the carbonization of bamboo/wood remains in the bamboo charcoal/charcoals.

By soaking them in an AgNO_3 aqueous solution, the hydrogen which exists in charcoals reduces silver ions and silver deposit.



Charcoal

Verification

Silver deposition from two types of carbon rods.

Carbon rods are made under high temperature and contain almost no hydrogen, so silver will not deposit from carbon rods if our hypothesis is correct.

[Experiment]

We put a carbon rod into AgNO_3 aqueous solution and tested whether silver deposit from it.



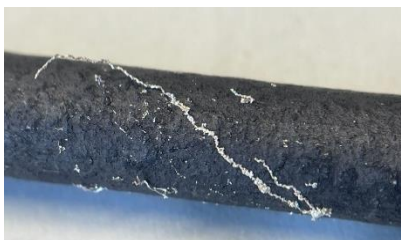
Result: silver did not deposit from a carbon rod.

Fig. 2 The carbon rod soaked in AgNO_3 aq

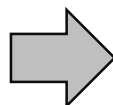
Next, we thought that if our hypothesis is correct, silver will deposit from a carbon rod by absorbing hydrogen.

[Experiment]

We made a carbon rod adsorbing hydrogen by using electrolysis of water and put it into AgNO_3 aqueous solution. After that, we checked whether silver deposit from it.



Result: silver deposited from a carbon rod absorbing hydrogen.



Our hypothesis is now more plausible.

Fig. 3 The carbon rod adsorbing hydrogen

However, we had a interrogation about our hypothesis.



How does hydrogen exists inside charcoals?

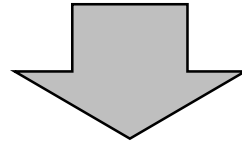
Possible ways to exist

Chemisorb

Physisorb

Spatially confined

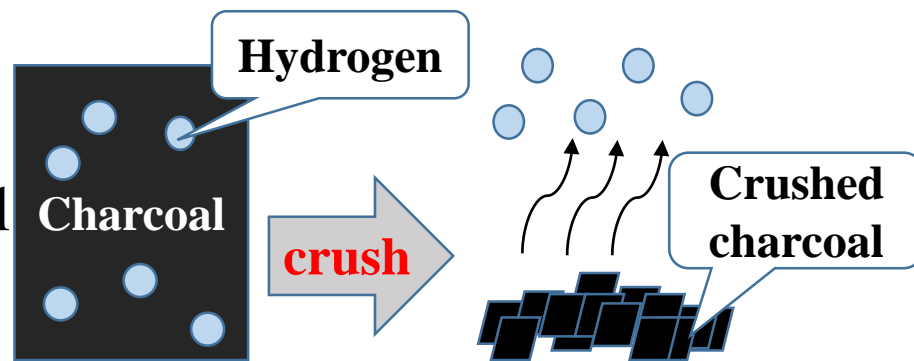
But, according to the reference⁴⁾,
the amount of physisorbed hydrogen by charcoals is extremely small.



In this research, we conducted experiment about
the case of chemisorb and **the case of spatially confined.**

The case of spatially confined

If hydrogen is spatially confined, hydrogen will escape from a charcoal by crushing it.



[Experiment]



Fig. 4 Solid charcoal and powdered charcoal

1.00 g each of powdered charcoal (particle size is 53 μm or less) and a solid charcoal were soaked in an AgNO_3 aqueous solution (0.5 mol/L) for 20 days. After that we measured the amount of deposited silver by the Mohr method.

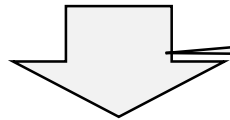
[Result]

	Deposited silver	Amount of titration
Powdered charcoal	0.235 g	11.7 mL
Solid charcoal	0.247 g	11.8 mL

Hydrogen is not spatially confined in the charcoal.
Moreover, hydrogen is strongly adsorbed on the charcoal.

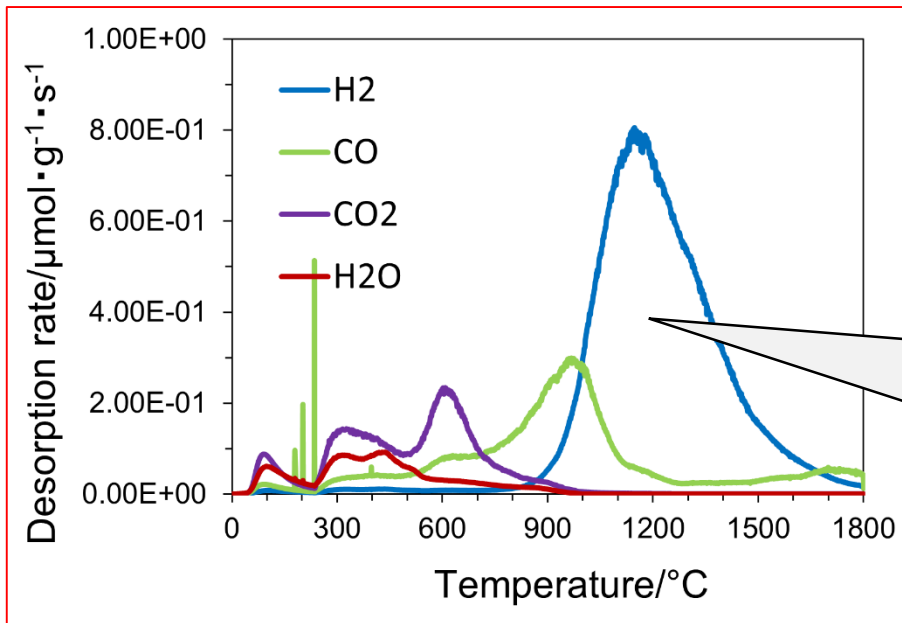
The case of chemisorb

According to the reference⁵⁾,
the surface edge of graphite and hydrogen make C-H bonds.



We wondered charcoals also have C-H bonds.

We conducted TPD(temperature-programmed desorption) method of bincho charcoal



[Result]

A large amount of **hydrogen** desorbed at around 1,200 $^{\circ}\text{C}$.

Fig. 5 The result of TPD method

We ascertained that

there are many C-H bonds on the surface edge of the charcoal

Summary

From these experiment,
we made a hypothesis about the reaction.

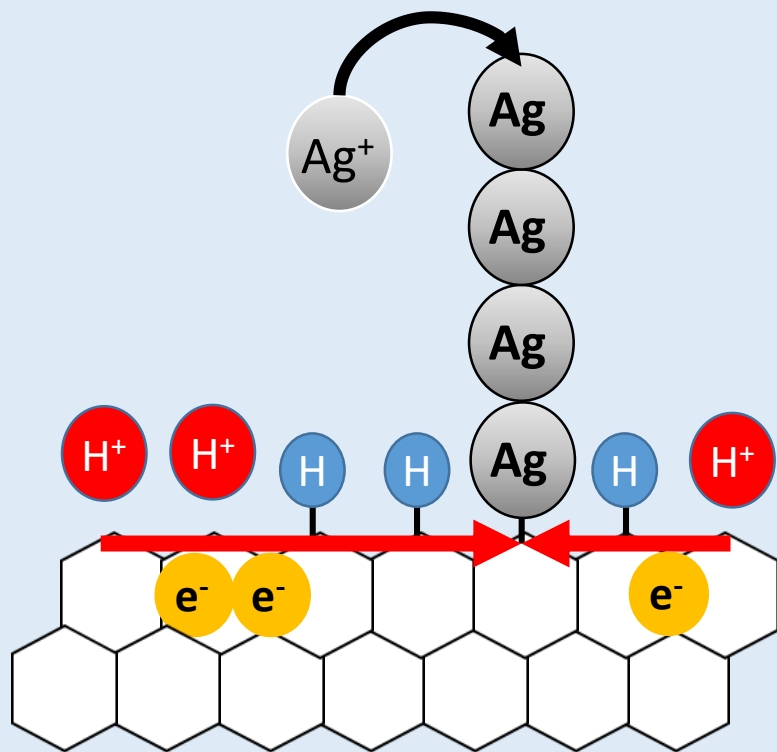


Fig. 6 Hypothetical diagram of the reaction

Hydrogen which was generated during making bamboo charcoal and charcoal is adsorbed on its surface edge as a C-H bond.

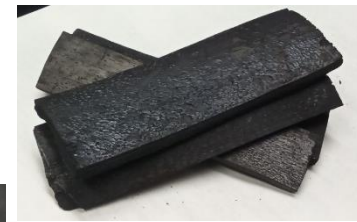
Moreover, silver is deposited by hydrogen reducing silver ions.

Application

From our research, we wondered that charcoals deposit metals from liquid waste.

We soaked charcoals in liquid waste which contained Cu^{2+} , Ag^+ , and $[\text{AuCl}_4]^-$.

We found a way to use of charcoals to **liquid waste management**



Cu^{2+} , Ag^+
and $[\text{AuCl}_4]^-$

Fig. 7 bamboo charcoals and metals deposited on charcoals

Also, we tried to express the beauty of the charcoals silver deposited as an artwork.

We created an artwork using charcoals silver deposited with a motif of “Karesansui*2”

We found a way to use of charcoals as **materials for Artworks**



Fig. 8 Artwork using charcoals silver deposited

Conclusion

We clarified the cause of silver deposition is **reduction of silver ions by hydrogen included the charcoal.**

We hypothesized that hydrogen is chemisorbed in the charcoals. And, the hypothesis was proved to be a strong one by using TPD method of the bincho charcoal.

Treatment of liquid waste containing metal ions and materials for artworks.

We explored the possibilities of charcoals.

Additional Explanation

*1 Bincho charcoal: A charcoal made from *Quercus phillyraeoides* (high grade oak)

*2 Karesansui : Traditional Japanese rock garden

reference

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