Strong interaction between protein and precious metal ions has potential to be utilized for recycling of precious metal ions

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Introduction

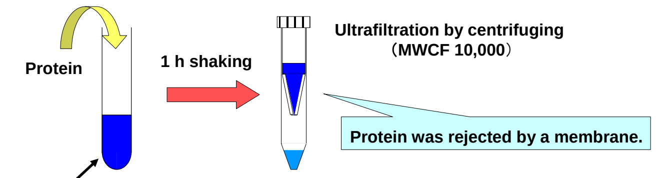
Proteins have various functional groups in their own structures. Some of them have specific interaction with metal ions and the interaction often plays an important role in a living cell and in enzymatic reaction. The specific interaction of proteins with metal ions has potential to serve for a selective separation of a targeted metal ion. For example, a thiol group, which exists in a protein molecule, has a strong interaction with gold and palladium. In this study, we take proteins as an novel adsorbent material and investigated the interaction between proteins and a noble metal ion (Au(III))

Objectives

- **To reveal interaction between proteins and a Au(III) ion.**
- **To develop the highly selective separation system using protein as an an adsorbent.**
- **Use of protein-rich biomass (soy protein) as an adsorbent for recycling of metal ions.**

Experimental

Metal ions	Au,Pd,Pt,Cu,Fe,Zn	Each10 ppm
Proteins	Lysozyme, Ovalbumin, Bovine Serum Albumin,	0.2 g/L



The concentration of metal ions in the filtrate was determined by atomic adsorption spectrophotometer.

Results & Discussion

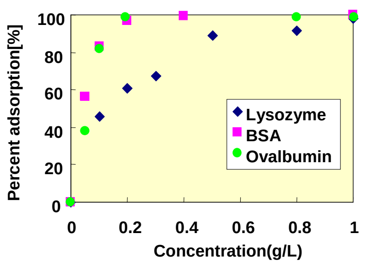
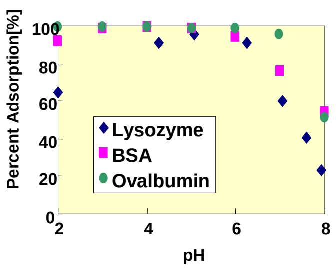


Fig. 1 Effect of protein concentrations on the Au(III) adsorption at pH 4

As the protein concentrations increased, the metal ions in the filtrate decreased. The Au ions were adsorbed on various proteins.



Forms of Au ions in an aqueous solution

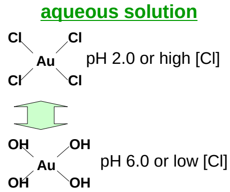


Fig. 2 Effect of pH on metal adsorption to proteins（[protein]=1.0 g/l）

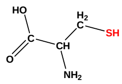
The adsorption of Au ions on protiens depended on pH of an aqueous solution.

Electrostatic interaction between Au ions and proteins?

Effect of dissolving form of Au ions, which varies with pH?

Discussion on Adsorption Mechanism

Thiol groups in a BSA molecule



Cystein

Without adsorption	0.61
After adsorption	0.14

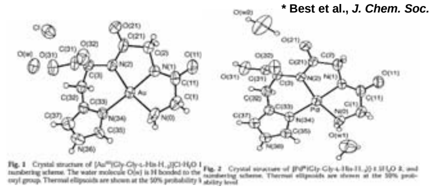
(Determined by 2,2-dithiodipyridine)

→ Metal-S (metal mercaptide) bond involved with the adsorption.

However, thiol groups = the total adsorbed Au ions

Au-peptide complex with N-Au bonds

* Best et al., *J. Chem. Soc., Dalton Trans.*, 1997, 2587



Tripeptide(Gly-Gly-His) forms complexes with a Au ion and a Pd ion.

→ **His residues also plays an important role in our study?**

Table 1 Au ions adsorbed on the proteins

	Lysozyme	BSA	Ovalbumin
His residue	1	17	7
SH group	0	0.7	4
Au ions per a protein molecule	1	17-18	11-12

Adsorbed Au ions = SH + His → **Metal-S bond and His-Au bond caused the Au adsorption.**

Above investigations suggest that protein-Au interactions were electrostatic interaction, metal-S bond and His-Au bond.

Practical investigations

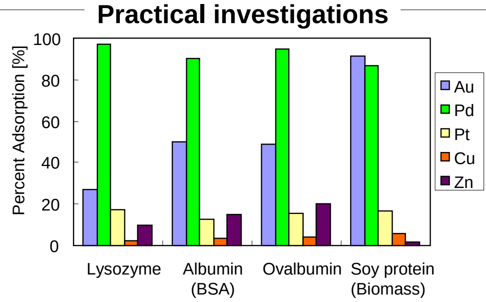
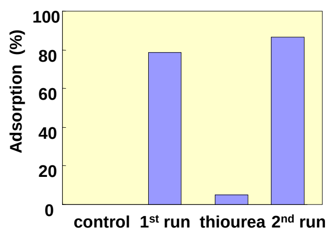


Fig .3 Competitive adsorption of metal ions on various proteins
([protein]=0.2 g/L, pH 4)

All the proteins tested exhibited high affinity to noble metal ions (Au and Pd). This means that **proteins can be employed for selective separation of noble metal ions from mixture of various metal ions.**



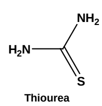


Fig. 4 Adsorption of Au ions on lysozyme immobilized on celite particles and detachment by thiourea.

Immobilized protein also adsorbed Au ions and the adsorbed Au ions were detached by the addition of thiourea. **Immobilized protein can be used as an adsorbent repeatedly.** An aqueous solution (7.0 ml, pH 4.0) containing 10 ppm Au ion and Celite 1.0 g with lysozyme 7.0 mg were used. Added thiourea for detachment was 2 mmol/L.

Conclusions

1. **Ovalbumin, BSA, lysozyme, casein sodium salt could adsorb noble metal ions at low pH.**
2. **The metal adsorption was due to electrostatic interaction, mercaptide bond and chelate formation by histidine residues.**
3. **Inexpensive proteins existing in biomass will be applied to the recycling system for noble metal ions.**