



# HOKKAIDO UNIVERSITY

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| Title               | Exploring the antibacterial mechanism of colloidal platinum nanoparticles on Streptococcus mutans                                                                                |
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| Description         | この博士論文の全文は利用可能日以降に公開されます。利用可能日以前の閲覧方法は <a href="https://www.lib.hokudai.ac.jp/dissertations/copy-guides/">https://www.lib.hokudai.ac.jp/dissertations/copy-guides/</a> をご参照ください。 |
| Degree Grantor      | 北海道大学                                                                                                                                                                            |
| Degree Name         | 博士(歯学)                                                                                                                                                                           |
| Dissertation Number | 甲第16930号                                                                                                                                                                         |
| Issue Date          | 2026-03-25                                                                                                                                                                       |
| DOI                 | <a href="https://doi.org/10.14943/doctoral.k16930">https://doi.org/10.14943/doctoral.k16930</a>                                                                                  |
| Doc URL             | <a href="https://hdl.handle.net/2115/99775">https://hdl.handle.net/2115/99775</a>                                                                                                |
| Type                | doctoral thesis                                                                                                                                                                  |
| File Information    | Kening_Huang_summary.pdf, 全文の要約                                                                                                                                                  |



学位論文内容の要約

Dissertation Summary

学位論文題目

Exploring the antibacterial mechanism of colloidal  
platinum nanoparticles on *Streptococcus mutans*  
(プラチナナノコロイドの *Streptococcus*  
*mutans* に対する抗菌作用機構の探索)

歯科保存学：博士（歯学）

氏名：Kening Huang

#### Abstract:

This study investigated the main antibacterial mechanism of colloidal platinum nanoparticles (CPNs) against *S. mutans*—a major caries-associated bacterium. The bacteria were subjected to varying quantities of the particles, and alterations in their activity, internal stress levels, and the excretion of cellular contents were assessed. Their surface morphology was examined using a high-magnification microscope. The results indicate that platinum particles inhibit bacterial growth by disrupting the cell surface and causing the loss of intracellular components. Unlike many antimicrobial therapies that exacerbate harmful internal stress, these particles effectively alleviate this stress, suggesting a gentler yet more effective method of disrupting bacterial integrity. Observable damage at the cell surface corroborated this explanation.

#### Summary:

This study shows that colloidal platinum nanoparticles (CPNs) exhibit unique antibacterial effects against *Streptococcus mutans*. Many metal-based nanoparticles, particularly silver and gold, exhibit antibacterial characteristics through oxidative stress mechanisms and the generation of reactive oxygen species (ROS). Our findings reveal a different mechanism. The CPNs inhibited bacterial viability without raising ROS level, instead exhibiting a ROS-lowering effect. This behavior aligns with the catalytic antioxidant properties reported for platinum nanozymes, which can function as catalase- or SOD-mimetics. This ROS-scavenging capability is especially significant.

CPN causes significant membrane disruption accompanied by a decrease in ROS levels, as confirmed by increased protein leakage and extensive cell wall rupture observed by scanning electron microscopy. Membrane damage has been extensively documented in research concerning noble metal nanoparticles, including those based on Ag, Au, Pt, and Pt–Ag systems. The bacterial membrane rupture and protein leakage observed in this study support the hypothesis that CPNs disrupt the structural integrity of *Streptococcus mutans*.

The oral significance of *Streptococcus mutans*, a primary causative agent of dental caries, highlights the translational relevance of these findings. Given the MIC of 0.5 mM determined in this study, CPNs may be suitable for incorporation into dental materials, such as orthodontic brackets, adhesives, coatings, and resin systems.

After being exposed to CPNs, the ROS levels in *Streptococcus mutans* decreased. Platinum nanozymes that can switch between redox states, on the other hand, have been shown to change oxidative microenvironments by breaking down peroxides and taking up free radicals. The lowered ROS levels observed here are therefore consistent with known platinum chemistry.

Finally, this work provides insights into the rational design of antimicrobial dental materials. Nanoparticles that combine membrane-disruptive activity with controlled redox behavior may mitigate unwanted oxidative stress while maintaining antimicrobial potency. Nonetheless, limitations remain. All experiments were performed in planktonic cultures, and biofilm models—more representative of the oral cavity—should be examined in future research.