



Title	Microalgae-Mediated Synthesis of Functionalized Gold Nanoparticles: Insights into Stability, Biocompatibility, and Photothermal Efficiency
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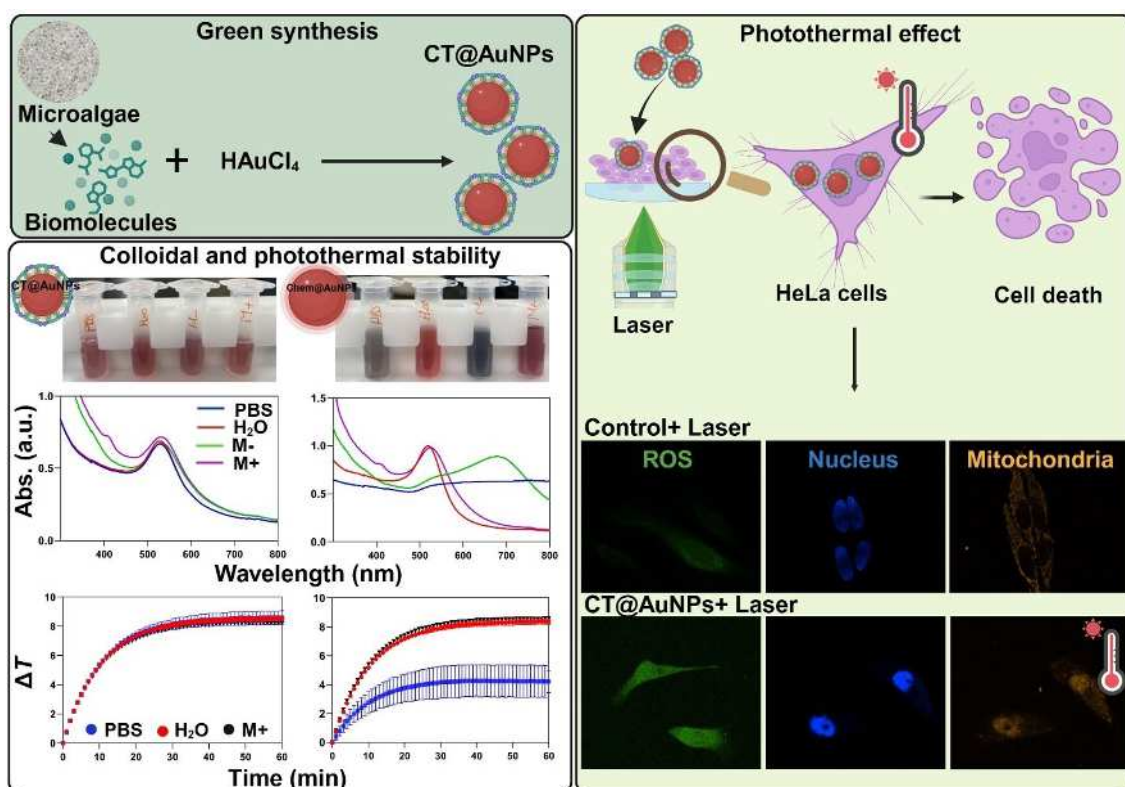
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The University of Osaka

Abstract of Thesis

Name	(Reham Samir Hussein Mohamed Hamida)
Title	Microalgae-Mediated Synthesis of Functionalized Gold Nanoparticles: Insights into Stability, Biocompatibility, and Photothermal Efficiency (微細藻類を利用した機能化金ナノ粒子の合成：安定性・生体適合性・光熱変換効率に関する包括的評価と考察)
Abstract of Thesis Gold nanoparticles (AuNPs) possess distinctive optical and plasmonic properties, particularly localized surface plasmon resonance (LSPR), making them promising candidates for biomedical and photothermal applications. Despite their potential, their susceptibility to aggregation and poor colloidal stability together enhance their cytotoxicity and limit their therapeutic potential, particularly in photothermal therapy. Here, we established a one-pot, sustainable, controlled, and surfactant-free synthesis approach using aqueous extracts of various microalgae to produce surface-functionalized, small AuNPs with high colloidal stability, enhanced photothermal efficiency, and biocompatibility. Systemic optimization of reaction conditions enabling the synthesis of small and well-dispersed AuNPs with controlled sizes and various morphologies. Hydrodynamic diameters (HDs) varied across microalgae-derived AuNPs with negative surface charges. Fourier transform infrared spectroscopy showed that biogenic AuNPs possess stable surface functionalization mediated by an algal corona composed of proteins, polysaccharides, and lipids. This corona provides amphiphilic and slightly negative layers on AuNP surfaces. Such a layer minimizes electrostatic interactions between AuNPs, thereby preventing their aggregation and enhancing their stability. Biogenic AuNPs demonstrated great colloidal stability (up to 48 h) compared to chemically synthesized AuNPs (Chem@AuNPs) indicated by unchangeable HDs of 26.8 ± 10.3 nm and 19.2 ± 6.1 nm, respectively. Under continuous laser stimulation for 1 h, AuNPs increased the temperature by ~ 8 °C, indicating efficient photothermal responses. Cytotoxicity assays displayed that biogenic AuNPs were markedly more selective toward malignant cells, inducing $\sim 70\%$ HeLa cell death upon laser ablation while revealing minimal or no toxicity toward kidney and liver cells. Conversely, Chem@AuNPs induced severe cytotoxicity in Vero and BNL cells. Analysis using 2',7'-dichlorodihydrofluorescein diacetate and morphology confirmed that the AuNP-induced cell death is likely due to the synergistic effects of LSPR-mediated hyperthermia and photo-induced reactive oxygen species generation. Overall, these findings highlight microalgae as robust and sustainable bionanofactories for synthesizing small, stable, and highly biocompatible AuNPs. The enhanced interfacial chemistry and stability of AuNPs contributed to the formation of an algal corona, addressing the challenges of chemically synthesized AuNPs and providing a promising alternative for photothermal therapy and other biomedical applications.	



Microalgae-derived AuNPs with high colloidal stability and effective photothermal efficacy.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨 金ナノ粒子は細胞内での特異的蛋白質モニタリング等に用いられ、またその光熱変換効果によりがん等の疾患治療への応用も期待されている。金ナノ粒子は化学的に調製することが一般的であるが、有毒な試薬が必要、安定性が低い等の問題があり、より環境に負荷がかからず、安価で安全なナノ粒子調製法がもとめられていた。これまでに一部の藍藻を用いた調製法が報告されていたが、藻類の違い、あるいは調製条件の違いによる金ナノ粒子の性状や性質について幅広く検討されたことはなかった。 本論文 (Microalgae-Mediated Synthesis of Functionalized Gold Nanoparticles: Insights into Stability, Biocompatibility, and Photothermal Efficiency) では、新種 9 種類を含む 10 種類の微細藻類を用いて金ナノ粒子の調製を行い、その違いを詳細に解析した。そして、得られた金ナノ粒子はいずれも化学的に調製したものより安定性が高く、また細胞毒性も低いことが明らかとなった。また細胞に吸着後、光照射すると細胞の生存率が低下することから、よい熱変換効果を持つことが実証された。以上のように、微細藻類を用いて効率的に金ナノ粒子を得る方法を確認し、今後の金ナノ粒子応用研究の発展に大きく寄与する成果が得られた。よって、本論文は博士 (理学) の学位論文として十分価値あるものと認める。			