Fe and Au/Fe Nanoparticle Influence on Bacteria and Biosurfactant Production

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Abstract
Effect of Fe and Au/Fe nanoparticles on the growth of UH-biosurfactant producing bacteria-*Serratia*, and the biosurfactant production was studied. Results showed that at a concentration of 1 mg/L of Fe nanoparticle, *Serratia* colony number increased by 57%, and biosurfactant production increase by 63%. Test result showed that Fe nanoparticles in the range of 1~10 mg/L had a positive impact on the bacterial growth and biosurfactant production. Fe/Au nanoparticle had a positive impact up to1 mg/L.

1 Introduction

Studies have shown that nanoparticles have anti-bacterial properties leading to physical destruction of bacteria with cell wall breakage or causing oxidative stresses and severe lipid peroxidation for bacteria with reactive oxygen species (ROS) generated (Wiesner et al. 2006). However, hypothesis is that other unique properties of nanoparticles may also provide benign effects to bacteria. Larger surface area of nanoparticles makes more ion released into the environment, these ions may further enhance bacteria activity. Electrons generated by nanoparticles may enhance enzymatic function of external membrane proteins, and may expedite electron transport chain in cells, thus metabolite of the cells. Besides, for bimetallic nanoparticles, which can form a primary cell itself, may further stimulate electron transport in biological cells by the electrons generated as the existence of potential difference of the two metals. Gold, the precious metal, has very low biological toxicity, as metallic gold is inert to all chemicals it encounters inside the cells (http://en.wikipedia.org/wiki/Gold). Gold nanoparticles are widely used in bioimaging, biosensors, biolables, and biomedicals (Das et al. 2009). Iron, the most common metal in daily use, is essential to nearly all known organisms, and is required by many bacteria (http://en.wikipedia.org/wiki/Iron). Some studies showed that zerovalent or ferrous iron nanoparticles are toxic to bacteria, while chemically stable nanoparticles (γFe_2O_3) or microscale Fe^0, or partial oxidation, or surface modified iron nanoparticles have no to some inactivation to bacteria (Auffan et al. 2008; Lee et al. 2008; Phenrat et al. 2009).

2 Objective

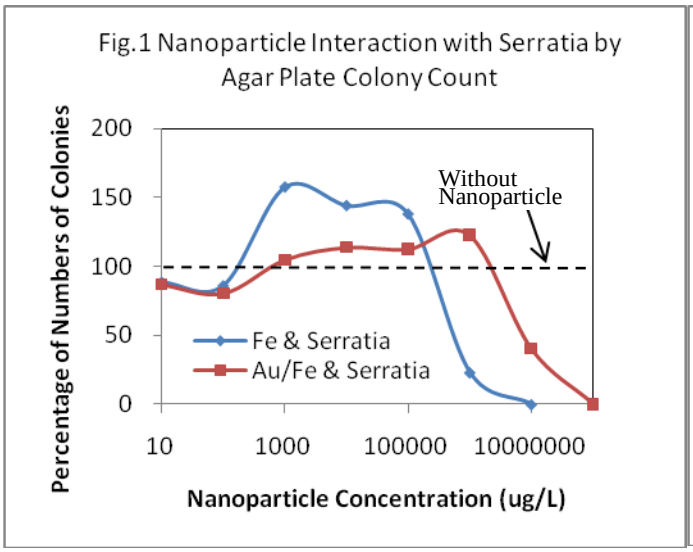
The objective was to investigate the effect of Fe and Au/Fe nanoparticle on the growth of biosurfactant producing bacteria-*Serratia*, and on the biosurfactant production.

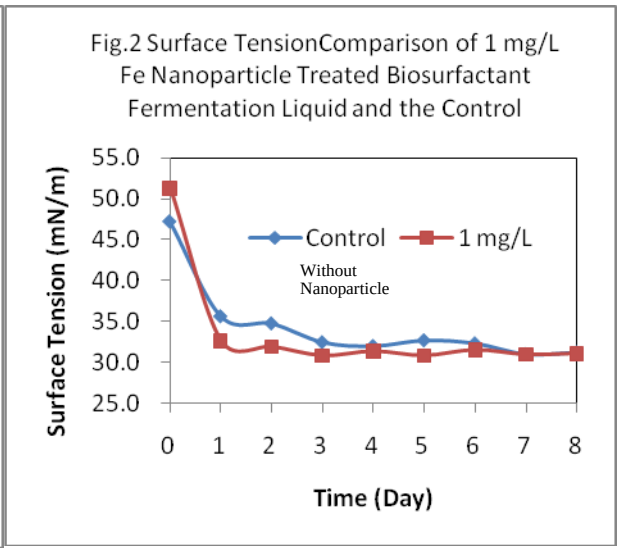
3 Materials and Methods

The quantity of biosurfactant production, surface tension of fermentation liquid, and bacteria growth were measured with the addition of Fe and Au/Fe nanoparticle concentrations of 10 μg/L, 100 μg/L, 1 mg/L, 10 mg/L, 100 mg/L, 1 g/L and 10 g/L. After 1 h interaction between nanoparticles and bacteria, liquid containing the bacteria was placed on agar plates. Colony numbers were measured after 1 day incubation. At least three samples were used under each testing condition.

4 Results and Discussion

Addition of Fe and Au/Fe nanoparticles on the growth of *Serratia* was investigated. Up to 100 µg/L, both types of nanoparticles had similar harmful effect on the growth. From 1 mg/L to 100 mg/L of Fe nanoparticle, or to 1 g/L of Au/Fe nanoparticle, bacteria colonies increased compared to the condition of without nanoparticle addition. After that, the colony number sharply decreased for both, to no colony at very high concentrations. Addition of 1 mg/L of Fe nanoparticle had the highest *Serratia* colony number which increased by 57%. (Fig.1). Addition of 1 mg/L of both Fe and Au/Fe nanoparticle mostly enhanced the biosurfactant production, with 63% and 40% increase respectively. Results also showed that *Serratia* grew better in the initial and later growth stages in the fermentation process under 1 mg/L of Fe nanoparticle (data not shown here), and the surface tension of the fermentation liquid was lower than the control of without nanoparticle during the process (Fig.2).





5 Conclusions

Addition of Fe and Au/Fe nanoparticles had increased bacterial growth, *Serratia* colony, and biosurfactant production with limited concentration.

6 Acknowledgements

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7 References

Auffan M. et al. (2008). Relation between the redox state of iron-based nanoparticles and their cytotoxicity toward *Escherichia* coli. Environ Sci Technol 42: 6730-6735

Das S.K., Das A.R., Guha A.K. (2009). Gold nanoparticles: microbial synthesis and application in water hygiene management. Langmuir. Doi: 10.1021/1a900585p

Lee C., Kim J.Y., Lee W.I., Nelson K.L., Yoon J., Sedlak D.L. (2008). Bacterial effect of zero-valent iron nanoparticles on Escherichia coli. Eniron Sci Technol 42: 4927-4933

Phenrat T., Long T.C., Lowry G.V., Veronesi B. (2009). Partial oxidation ("aging") and surface modification decrease the toxicity of nanosized zerovalent iron. 43 (1): 196-200

Wiesner M.R., Lowry G.V., Alvarez P., Dionysiou D., Biswas P. (2006) Assessing the risks of manufactured nanomaterials. Environ Sci Technol July 15: 4336-4345