MICROWAVE-ASSISTED FLOW MANUFACTURING OF VALUE ADDED MATERIALS

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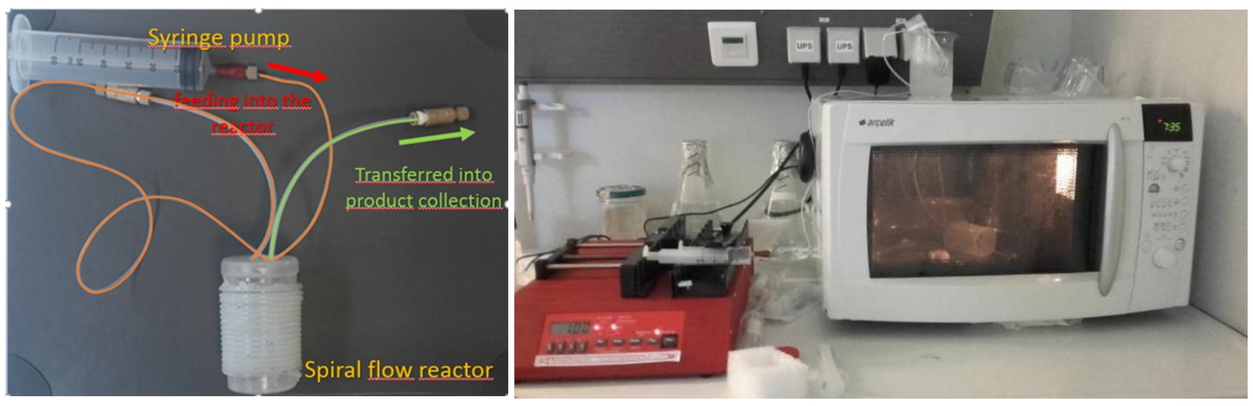
AIM

This research aims the synthesis, spectroscopic characterization and comparison of silver nanoparticles (AgNP) by using conventional and microwave energy in flow and batch systems.

INTRODUCTION

Microwave energy is used as energy source in processes requiring energy and becomes alternative for conventional heating methods[1]. During microwave irradiation, energy conversion occurs from electromagnetic energy to internal energy in the material[2]. Due to limited penetration of MW energy, tubular flow reactor is integrated with MW to enhance heat transfer[3]. In MW-assisted flow system, materials interacting with microwaves are heated to a high temperature within short period[4]. Homogenous heating is achieved by reducing reaction times. In addition to less energy and cost, the system is easily controlled[2]. Smaller size and narrower size distribution of AgNP can be produced compared to conventional methods[5].

MICROWAVE-FLOW SYSTEM DESIGN



a b

Fig. 1. (a) Spiral flow reactor (b) Our microwave-assisted flow system

SILVER NANOPARTICLE PRODUCTION

$$AgNO_3 \xrightarrow[H_2O]{\text{Trisodium Citrate}} \text{Ag NPs}$$

5 ml of 0.01 M sodium citrate was added to 50 ml of 0.001 M $AgNO_3$. All solutions were prepared in distilled water. The mixture was sent to the reactor via syringe-pump. The solution leaving from the reactor was collected in ice-bath placed above the microwave.

RESULTS&DISCUSSION

✓ Microwave Power

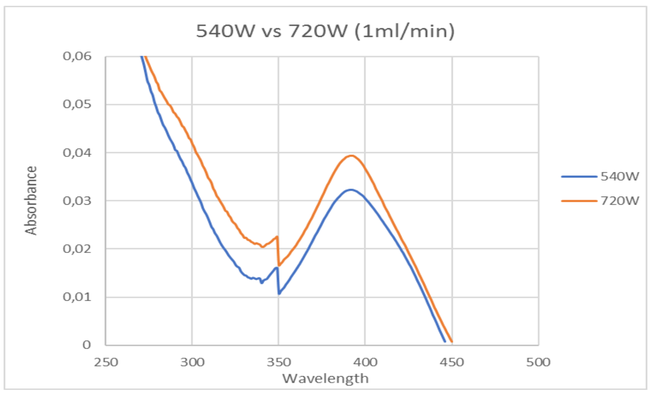
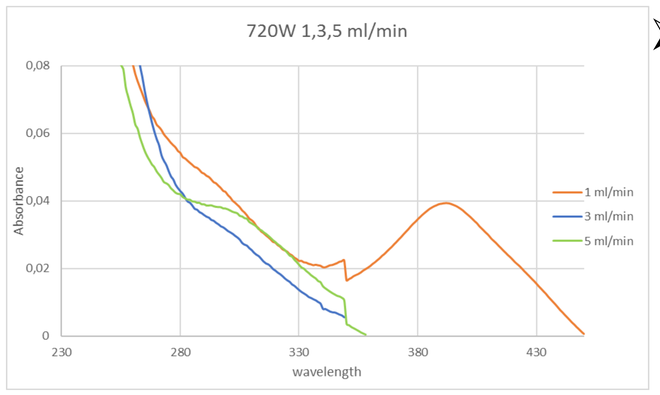


Fig. 2. microwave power effects

- Ag NPs were produced under 540W and 720W.
- As it could be seen from the graph, absorbance value at the peak point increases with increasing MW power.
- Since absorbance value is proportional to AgNP concentration in the solution, the AgNP concentration of the solution produced under 720 W was higher.

✓ Flow Rate



a

Flow Rate	Residence time in the reactor
1 ml/min	5.5 min
3 ml/min	1.83 min
5 ml/min	1.1 min

b

Fig. 3. (a) 1,3,5 ml/min under 720W (b)flow rate vs time

- High flow rate causes the solution to flow quickly through the reactor. The solution can not get enough energy for the reaction. For 3ml/min and 5 ml/min flow rate using 720W, Ag NPs production was not been observed due to less residence time.
- 5.5 minutes were required to produce Ag NPs under 720W.

✓ Reactor Type

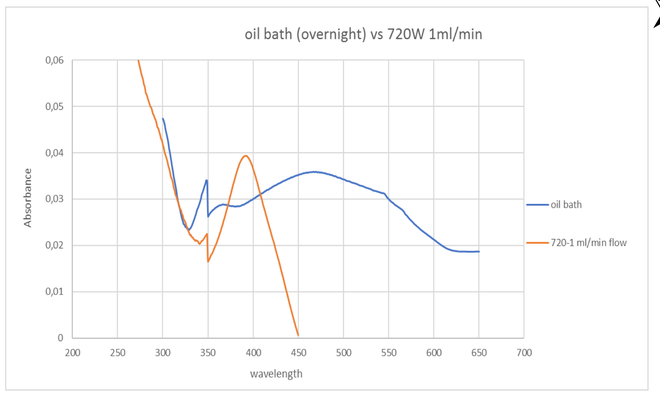


Fig. 4. oil bath vs MW-flow system

- Ag NPs were produced approximately within 5.5 minutes by using MW-flow system. However, they were produced within 30 minutes by using oil bath-batch system. Concentration of Ag NPs is higher in MW-flow system due to high abs value.

CONCLUSION

In our study, we observed that Ag NPs can be produced by using MW-assisted-flow system. Compared to oil bath, it was hypothesized that nanoparticles have narrower particle size distributions. Full width at half maximum (FWHM) was between 359-427 nm under 720W 1ml/min MW-flow system and the FWHM for oil bath-batch system was approximately 3 times wider than MW-flow system. According to this, particle size distribution in the MW-flow system is narrower than oil bath-batch system. We also observed that Ag NP production is faster in MW-flow system (5.5 min) than oil bath-batch system(30 min).

To conclude, our MW-flow reactor system has potential for large scale production of silver nanoparticles. AgNPs concentration can be increased with scale-up system.

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