# MORPHOLOGY AND STRUCTURE OF PT-NI NANO COMPOSITE POWDER FABRICATED BY PULSED WIRE EXPLOSION PROCESS

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## 1. Introduction

Recently, pulsed wire explosion (PWE) method has been considered as an effective process to make nano-scaled metal powders compared with other techniques such as atomization, pulverization, reduction, and chemical method, it allows several remarkable advantages which can easily make nano-particles, modify structures, and avoid unwanted product during chemical reaction, etc, [2]. On the basis of the previous results, it has been reported that the super heating factor ($K$) or the specific energy input into the wire ($W/Ws$) influence to particle size, morphology, and its structure. The super heating factor depends on sublimation energy of metal wire, wire volume, and charging voltage. The super heating factor can be written as

$$K = W/Ws \quad (1)$$

$$Ws = V_{volume} \times w_s = \pi \times r^2 \times l \times w_s \quad (2)$$

Here, $Ws$ is the energy for sublimation of the wire, $w_s$ is the sublimation energy of metal, $r$ is radius of wire, $l$ is wire length. The productivity of nano-particles increases with increasing the super heating factor. In recent years, many studies for metallic nano-particles such as Al, Ag, Cu, Fe, W, and Ni using pulsed wire explosion method have been carried out. Among them, Pt nano-particles have been used for various applications such as in catalyst fields for fuel cell batteries, $CO_2$ reforming, and reduction of harmful gases from automobile, etc [3]. In addition, it has been reported a small amount of Pt can promote the catalytic activity of Ni catalysts for $CO_2$ reforming and stabilize its degree of reduction during the catalytic process. Recently, Pt, Ni and its alloy nano-particles for catalysts have been fabricated by chemical process because it can produce extremely fine metallic nano-particles of less than 100 nm in particle size. However, it has still several limitations such as formation of unwanted product during chemical process and low productivity. In this work, we tried to produce Pt-Ni nano-particles using pulsed wire explosion process and investigate its morphology and structure. For this, we fabricated Pt-Ni wires using an electroless plating. The aim of this work is to investigate the possibility of fabrication of Pt/Ni nano composite particles and understand its morphology and structure.

## 2. Experimental procedure

Fig. 1 shows the schematic of pulsed wire explosion system used in this work.

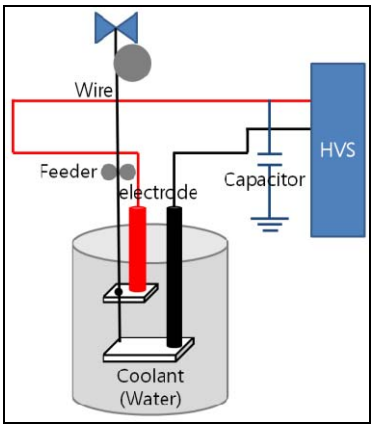



Fig. 1 Schematic of pulsed wire explosion system

Pt-Ni wire prepared by electroless plating about 10 um Ni on Pt wire (the diameter is 100 um) was used for this experiment. Fig. 2 shows the SEM images of cross-sectional plane of Pt-Ni wire. The volume fraction of Ni was approximately 30%. Wire

explosion was carried out into water coolant. HR-TEM and XRD were used to evaluate the particle morphology and structure. Zeta-potential analyzer was used to measure the particle dispersibility.

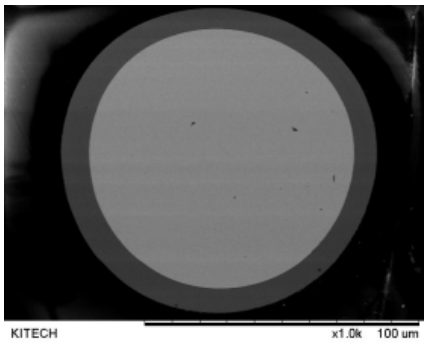



Fig. 2 SEM image of Pt-Ni wire (Ni 30%vol)

We set the explosion system of feeding length to 40 mm and the applied charging voltage to 300 V and exploded the wire in 250 ml distilled water. The total wire length, we exploded, was 30 m. Table 1 shows the condition of wire explosion for this work.

Table.1 the condition of wire explosion

| Sample | Wire diameter | Feeding length |
|---|---|---|
| Pt-Ni wire | 0.11 mm | 40 mm |
| Charging voltage | Total length | Solution |
| 300 V | 30 m | Distilled water (250 ml) |

## 3. Results and discussion

Fig. 3 shows the Pt-Ni colloid in 250 ml distilled water which was exploded about 750 times by pulsed wire explosion (PWE) process.


Fig. 3 Pt-Ni colloid in distilled water

Fig. 4 shows TEM micrographs and selected area diffraction pattern (SADP) of the produced powders by PWE process in distilled water. It is observed that the particles are of spherical in shape and the particle size lies in the range of a few nano-meter up to 150nm for Pt-Ni particles. According to the HR-TEM analysis, oxide layer and exfoliation crystalline layer were not observed. It's not seems to be oxidized or formed exfoliating crystalline layer during the explosion.

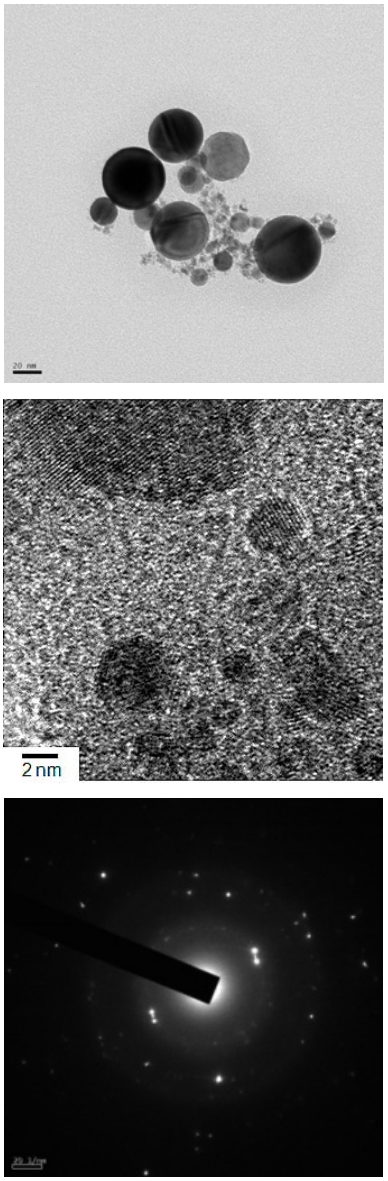
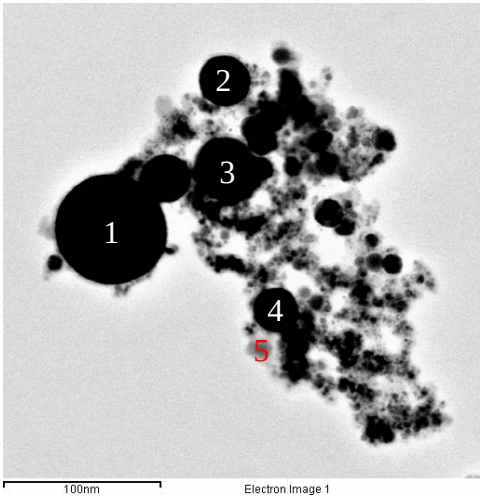
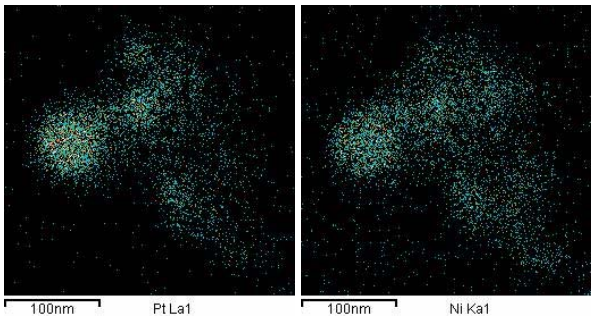



Fig. 4 TEM images and selected area diffraction pattern (SADP) of the Pt-Ni powders




(a)




(b) (c)

Fig. 5 EDX-mapping result of Pt-Ni particles

Table.2 Chemical composition of each points (1 ~ 5)

| Point | Pt | | Ni | |
|---|---|---|---|---|
| | Weight% | Atomic% | Weight% | Atomic% |
| 1 | 85.87 | 64.64 | 14.13 | 35.36 |
| 2 | 91.60 | 76.70 | 8.40 | 23.30 |
| 3 | 85.00 | 63.00 | 15.00 | 37.00 |
| 4 | 83.52 | 60.40 | 16.48 | 39.60 |
| 5 | 62.20 | 33.10 | 37.80 | 66.90 |

Fig. 5 and Table 2 show TEM-EDX and EDX mapping results. From Fig. 5b and Fig. 5c, it is found that both Pt and Ni elements are detected in most of particles and it indicates that both elements are solid solution. However, the ratio of Pt to Ni is not constant, as seen in table 2. Fig. 6 shows the XRD pattern of Pt-Ni particle and Pt particle fabricated by similar manner. Peaks corresponding to Pt phase and unknown peaks are simultaneously detected in XRD spectra of Pt-Ni nano particle. The unknown peaks would indicate that Pt is alloyed with Ni during pulsed wire explosion.

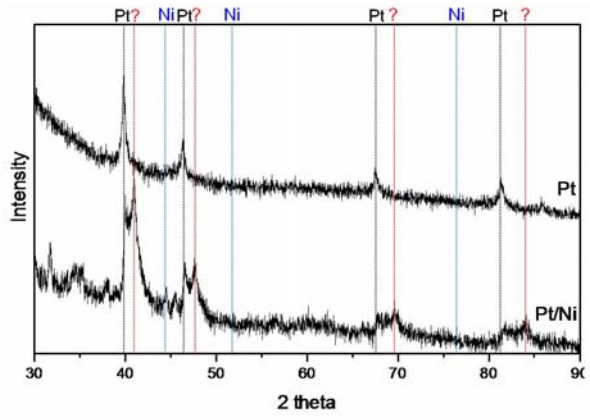



Fig. 6 XRD patterns of Pt-Ni nano particle and Pt nano particle

Zeta-potential is a method to identify the dispersivity of particles [4]. If zeta-potential is higher than ± 30 mV, it can be recognized that particles are stable. However, zeta-potential of Pt-Ni particles of the present work was estimated to about 19.91 mV.

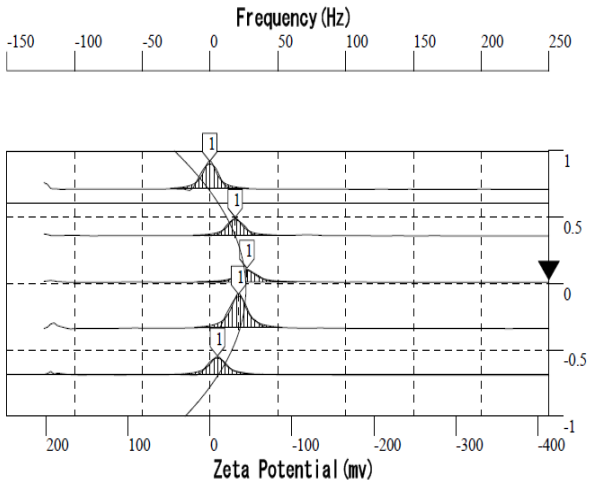



Fig. 7 Zeta-potential analysis of the particle size distribution

## 4. Conclusion

In this work, we could successfully fabricate Pt-Ni nano particles with the particle size of less than 50 nm using pulsed wire explosion process in distilled water. The produced Pt-Ni nano particles were of spherical in shape and exhibited solid solution type.

## 5. References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