Ultrasonic Effect on Wood Electroless Ni-P/nano-SiC Composite Coatings

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In this study, the particle size, wear resistance of coatings and the dispersibility of nano-SiC (size of 40 nm) by ultrasonic dealing with the plating solution to disperse nano-SiC particles were investigated. The crystalline and amorphous characteristics of the composite coatings was analyzed by X-Ray diffraction, surface morphology and element composition were investigated by scanning electron microscope equipped with energy diffraction spectrum. The wear resistance of coatings was measured using the rolling wear testing machine, indicating that the wear resistance increased by 50 % comparing with SiC free electroless Ni coating. The results showed that ultrasonic can decrease the particle size of wood surface coatings. Furthermore, ultrasonic had a significant effect on nano-SiC dispersibility and the structure of coatings maintained as nano-SiC particles embedded. Besides, the particles of wood surface coatings dispersed more homogeneous with the ultrasonic power up to 720 w, which promoted the Ni-P and nano-SiC particles distribution more compact.

Keywords: Wood electroless plating, Ultrasonic, Wear resistance, Nano-SiC, Particle size.

INTRODUCTION

The composite plating is the new progress for chemical plating technology. The basic principle is that amount of insoluble solid particles (SiC, SiO_2) with the coating metal is added into plating solution, to establish suspending homogeneously deposits on surface of substrates, demonstrating specific coating performances. It is known that particles embedded nickel phosphorus compound coating could provide different enhanced surface properties, according to the nature of particles[1-3], size and concentration[4,5]. Recently, the chemical composite plating has been attracted much attention in multifunctional applications, such as nickel phosphorus compound coating with ceramic particles (alumina)[6-11]. The insoluble nano-particles replaced micron-particles to form nanoscaled composite coating, which made the chemical composite plating possessing specific functions[12]. Some literatures[13] mentioned that the volume and surface area of the unit mass for nano-materials played significant effects on improving chemical composite plating. In general, mechanical dispersion as composite coatings, involved particles aggregation in the electrolyte, compared to the ultrasonic approach[14]. However, there were few reports focusing on wood surface nano-SiC chemical composite plating. Here, we prepared wood plating surface coating *via* ultrasonic method, expecting to decrease particle size and weaken aggregation of nano-SiC particles, achieving advanced abrasion resistance of wood surface coating.

EXPERIMENTAL

Nickel sulfate, sodium phosphate, sodium citrate, thiourea, ammonia, copper sulfate, EDTA disodium salt and potassium sodium tartrate were analytical reagent, respectively, poplar veneer, SiC (size of 40 nm), sand paper (600 mesh). BS110S type electronic balance, S212B-1-5L temperature vacuum stirring reaction device, PHS-2CA type precision acidity meter, DH-101-2-S type electric drum wind drying oven, W201B type thermostat water bath pot, tray balance, SM-1200D ultrasonic signal generator, XRD diffraction, S-3400N scanning electron microscope, rolling wear testing machine.

Detection method: The surface morphology of wood surface coating by S-3400N scanning electron microscope was investigated, the crystalline and amorphous characteristics of the composite coatings was analyzed using X-Ray diffraction (XRD) and the wear resistance of coating by the rolling wear testing machine was measured.

Wear resisting rate (v) = $\dfrac{(m_1 - m_0)}{st}$, v = wear-resisting rate, m_1 = quality of wood after abrasion test, m_0 = wood quality before wear-resisting test, s = wood surface area, t = wear-resisting test time.

RESULTS AND DISCUSSION

The morphology of chemical plating wood surface coating was observed by SEM images as ultrasonic power was 480

and 720 w, respectively (Figs. 1 and 2). There were amount of coarse particles that distributed in Fig. 1 while fewer coarse grains emerged in Fig. 2. These results clearly illustrated that the nickel particles of wood surface coating turned to be smaller dramatically with ultrasonic power increasing and the distribution of nickel particles in the coatings were more compact. The possible reason was attributed to the ultrasonic that might break the normal particles growth and destruction of the larger particles, which triggered the particles growth in smaller nuclei[14]. Thus, the ultrasonic had a significant effect on nickel particles nucleation growth during the process of electroless plating. It directly led to the particle size of the wood surface coating much smaller.

Fig. 3. XRD spectrum of wood surface ingredients

sharper, indicating that the particle size turned to be smaller and the crystallization enhanced comparably[16].

A number of small particles aggregated in Fig. 4, while the nano-SiC particles dispersed homogeneously in Fig. 5. The energy diffraction spectrum (Fig. 6) displayed these small particles were nano-SiC. Comparatively, the nano-SiC of the wood surface coating distributed non-uniform as the ultrasonic power was 600 w. However, with ultrasonic power increasing

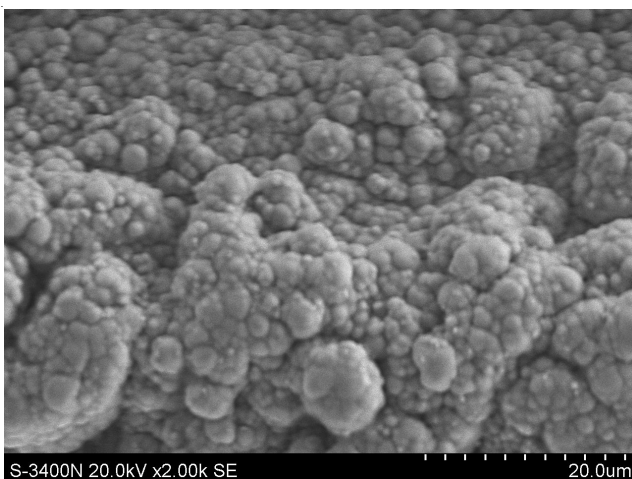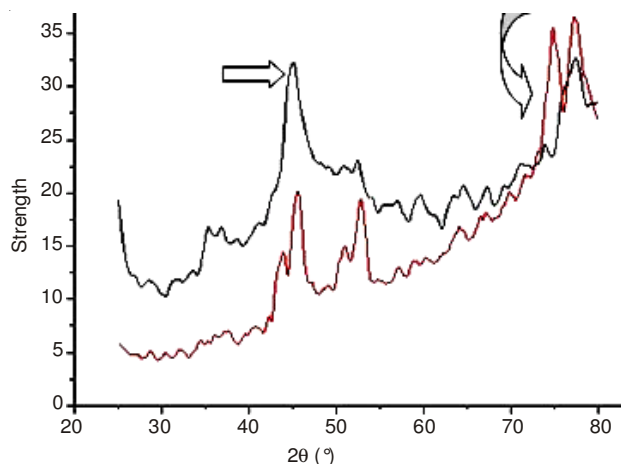Fig.1. Ultrasonic power is 480 w

Fig. 2. Ultrasonic power is 720 w

Fig. 3 showed the XRD spectra of nickel particles in wood surface coating (in black line) and another curve was after the ultrasonic power 720 w (in red line). In comparison, the crystalline structure showed obviously changes in the wood surface coating assisted by ultrasonic during chemical plating and the structure of coatings maintained even through nano-SiC particles were embedded[15]. Besides, some new diffraction peaks emerged from 70 to 80° comparing with the peaks of pure Ni. A compound phases might be formed between nickel particles and embedded nano-SiC particles. The half high width of diffraction peak obviously broadened and became
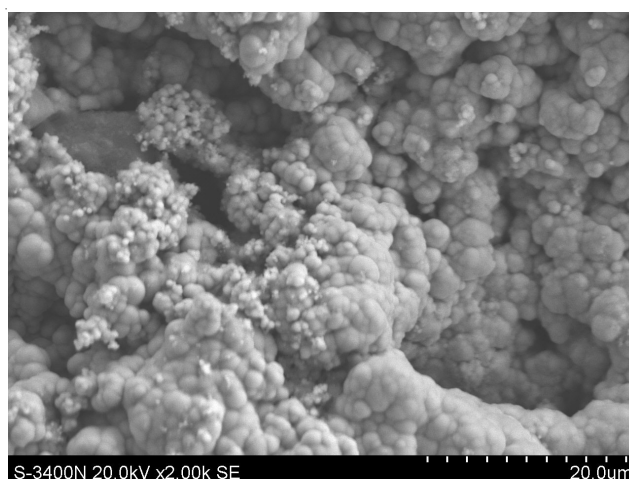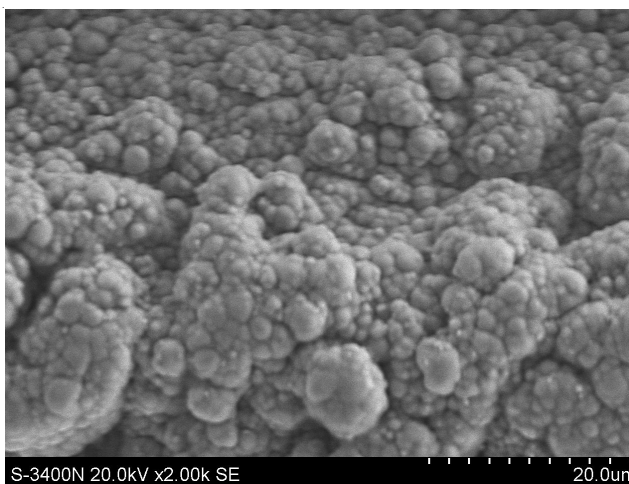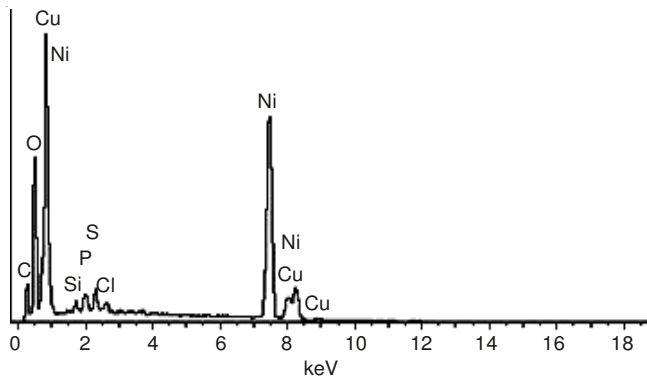
Fig. 4. Ultrasonic power is 600 w

Fig. 5. Ultrasonic power is 720 w

Fig. 6. Energy diffraction spectrum of SiC and Ni composites wood surface coating (600 w)

Fig. 8. Ultrasonic power is 480 w

Fig. 9. Ultrasonic power is 720 w

to 720 w, the nano-SiC particles exhibited more homogeneous and well-distributed. The reason was that nano-SiC particles aggregated faster as ultrasonic speed getting lower. In addition, nano-SiC could not deposit easily while the power increased. Nano-SiC and nickel particles co-deposited on the wood surface during the proceeding of electroless plating, additionally, ultrasonic approach can enhance dispersion uniformly and homogeneously.

The particles of coating distributed non-uniform on the wood surface in Fig. 7. Besides, there were some coarse particles which still aggregated even though these particles demonstrated non-uniform comparatively. And the wood surface coatings gradually tended to be smooth in Fig. 8 and the particles became significantly much smaller in comparison with Fig. 7. Furthermore, Ni-P-SiC composite coating exhibited a more compact structure and the wood surface was quite fine in Fig. 9. Briefly, the size of nano-SiC particles decreased as ultrasonic power was 720 w. In addition, the flatness of wood surface coating improved with nano-SiC particles dispersing more homogeneous, which promoted Ni and nano-SiC particles distributing compact and the thickness of wood surface was about 400 μm (Fig. 10).

With the time increasing, the quality of wood without nano-SiC particles varied much faster in comparing with the coatings containing nano-SiC particles as shown in Fig. 11. Furthermore, the quality of pure Ni coatings did not change after 60 s. However, the quality of wood containing nano-SiC declined all the time still up to 120 s. These results showed
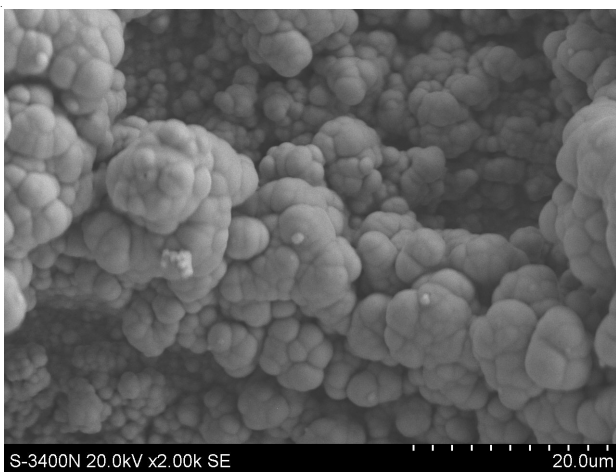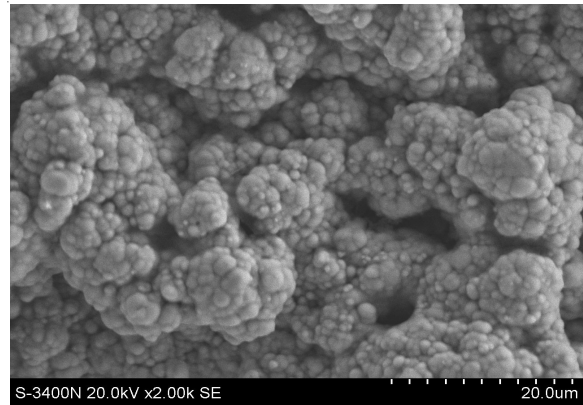

Fig. 10. Coating slitting diagram (720 w)

Fig. 7. Plated nickel wood surface coating
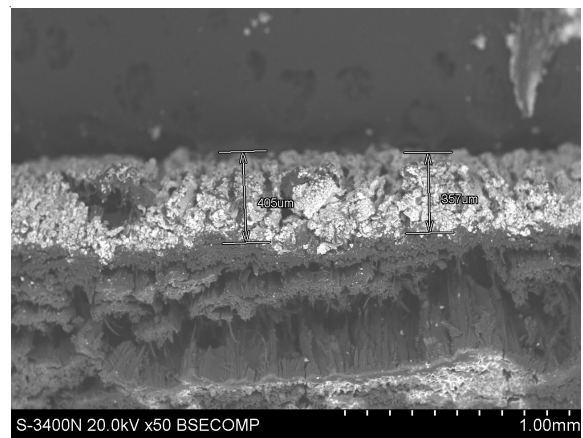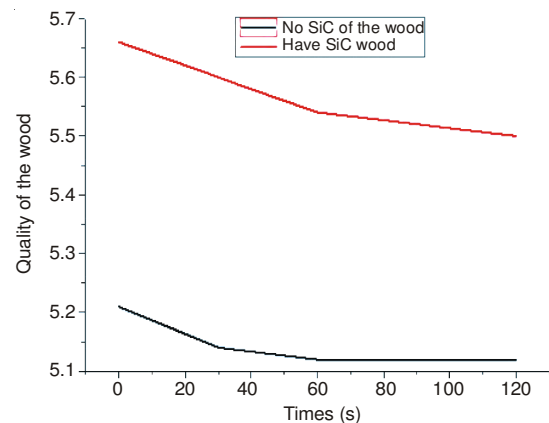

Fig. 11. SiC free and containing SiC wood wear-resisting

that the wear resistance of wood surface coatings containing nano-SiC particles increased by 50 %. Fig. 12 showed the quality of wood varied with different ultrasonic sonication intensity, it changed dramatically with ultrasonic power up to 480 w and would maintain its quality changes until time was 90 s. In contrast, the wood quality varied along with ultrasonic power 720 w, obviously, the wear-resisting time of wood surface coatings prolonged with ultrasonic power increasing, leading to the wear resistance improved. Especially, a better abrasion resistance emerged when ultrasonic power was 720 w. The possible reason was that SiC nanoparticles aggregated faster as ultrasonic power was low, which could inhibit the spread of the Ni^{2+} ions to permeate into the surface wood coating[17], thus the abrasion resistance was low due to insufficient Ni^{2+} depositing on wood surface. However, Ni^{2+} ions deposited much easier as ultrasonic power increasing, inducing SiC and nickel particles co-deposition. Therefore, abrasion resistance of the wood surface coating increased significantly. On the contrary, the wear resistance reduced gradually when the ultrasonic power increased beyond 720 w, which was in accordance with Guglielmi's adsorption.
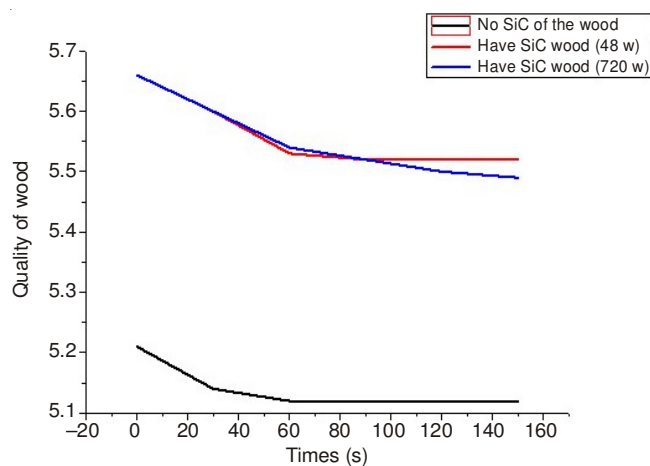

Fig. 12. Wear resistance under different power

Conclusions

In this study, all research highlights were summarized as following:

(i) The ultrasonic approach could mainly influence Ni particles nucleation and growth in the process of electroless plating. Furthermore, the particle size of wood surface coatings decreased and nano-SiC dispersed uniform.

(ii) The structure of coatings maintained as nano-SiC particles embedded. Besides, the wood surface coating dispersed homogeneously as ultrasonic power was up to 720 w, which promoted Ni and nano-SiC particles distributed more compact. The thickness of wood surface coatings was about 400 μm. Lastly, the wear resistance increased by 50 % in comparison with pure Ni particles coatings.

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