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## A STUDY OF HORSESHOE BONDING WITH GLUE FOR TREATMENT PURPOSE

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### ABSTRACT

*Horseshoes are fixed to hooves using metal nails. The nails can cause problems to horses, for example, germs can be formed around nail holes and it can cause some diseases to the horses. It also can cause moistures between the horseshoe and hooves which can cause disease as well. Moreover, the process of mounting is time-consuming and inefficient process. In this study, instead of mounting horseshoe on hoof using nails, we suggest the method of mounting using adhesives. Since horseshoe are usually produced in large quantities, it is necessary to perform a second task to adjust the shape of horseshoes to fit with hooves. However, when using glue, it may not need the secondary works because the adhesive fill the empty space between the hoof and horseshoe. Also, there is a risk of injuries to farriers due to the time required to install the horseshoe using nails. However, when fixing the horseshoes using adhesive, the method is much simpler, so the processing time can be much shortened and the risk of injuries can be much reduced. We suggest the adhesives suitable for the horseshoe replacement, and the properties of the adhesives were measured and presented.*

**Key words:** Horseshoe, Acrylic adhesive, Treatment, Bonding method, MMA.

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## 1. INTRODUCTION

The main component of horse hoof is a gelatin, which acts to alleviate direct impacts from the ground. The hoof is easy to wear, so horseshoes are mounted on the bottom of hooves. The horseshoes are generally in the shape of 'U', and the horseshoe not only protects the hooves but also helps to increase the horses' activity.[1-5] Typical horseshoes are made of steel and the weight is about 890 grams ~ 1,500 grams. If the weight of horseshoe becomes heavier, the horses' activity would be decreased. Therefore, horseshoe made of aluminum which is lighter material have been developed and used for specific purposes. For example, the weight of aluminum horseshoe is about 1/3 of the weight of steel horseshoe, so racing performance of racehorses can be much improved. Horseshoes usually require 6 to 8 weeks of lifetime. However, the aluminum horseshoes are weaker in strength and have shorter lifetime than required. Therefore, in order to increase the strength of the aluminum horseshoe, researches have been conducted to develop aluminum composite or other composite materials horseshoes.[5-9] A metallic horseshoe generally has a high strength but usually it cannot absorb impacts and so those impacts can be transmitted from ground to the horse directly. Therefore, horseshoes with materials which can absorb the impacts have been developed, for example, using a polymer or a rubber material. However, there are also disadvantages with those materials which are lower in strength and shorter in lifetime.

Typically, the horseshoes are mounted to the hooves using metal nails. The nails are used to help horse activity, but the nails can cause problems. For example, some germs can be formed around the nail holes and cause some diseases to horses. It also can produce moistures between the horseshoe and hoof which can cause disease as well. Moreover, mounting horseshoe using nails is time-consuming and inefficient process. In addition, every time the hoof touches the ground, the hoof bends due to the pressure and which can cause the nails to be loosen and cause the horseshoe to fall off and cause illness to horses.

In this study, instead of mounting horseshoes using nails, we studied the method of fixing the horseshoe using adhesives. The horseshoe should be fit with various shapes of hoof shape and should be designed for some specific purposes. Since horseshoe are usually produced in large quantities, it is necessary to perform a second task to adjust the shape of horseshoes. However, when using glue, fixing a horseshoe does not need secondary work because the adhesive fill the empty space between the hoof and horseshoe. Also, there is a risk of injuries for farriers due to the time required to install the horses using nails. However, when fixing the horseshoes using adhesive, the method is much simpler compared to the nail method, so the processing time can be much shortened and the risk of injuries can be much reduced. Moreover, the general person, not the experts, can carry out the replacement of the horseshoe because it is a much simpler and safer process.

## 2. DISCUSSION AND RESULT

The characteristics of adhesives required for bonding horseshoe are as follows.

- - Good adhesion
- - Resistant to water or other environmental things around horse
- - Temperature of curing process is low, so it should be comfortable to horse.
- - Curing time should be relatively fast
- - Bonding process should be simple

When a horseshoe is fixed by a nail, it should withstand a weight of more than 400 Kg, while general acrylic-based adhesives can withstand a weight of about 270 Kg. In this study, we planned to find adhesives that can endure the weight of over 500 kg at least. Epoxy-based

adhesives have the good chemical resistance properties, but they require surface treatment when bonding between target materials and have a longer curing time. Generally, acrylic-based adhesives have lower resistance to water than epoxy-based adhesives and have lower resistance to bleach and to alcohols. However, acrylic-based adhesives showed excellent resistance to oily substances and showed excellent anti-cooling property at low temperature. When acrylic-based adhesives and epoxy-based adhesives are compared, there is not a large difference in resistance to water, bleach and alcohol. As a result of comparisons, it is expected that the acrylic-based adhesives can be used for mounting horseshoes. Compared with urethane-based adhesives and acrylic-based adhesives, the urethane-based adhesives showed high resistance to water, bleach and alcohol, but there were not many differences. Compared with epoxy-based adhesives and urethane-based adhesives, acrylic-based adhesives did not show a great advantage in terms of environmental and chemical resistances.

Adhesives may lose its adhesive strength when the temperature rises. Epoxy-based adhesives can withstand about 170 degrees, and acryl-based adhesives can withstand about 120 degrees. It is considered that there is no problem in the case of using those two adhesives for bonding horseshoes.

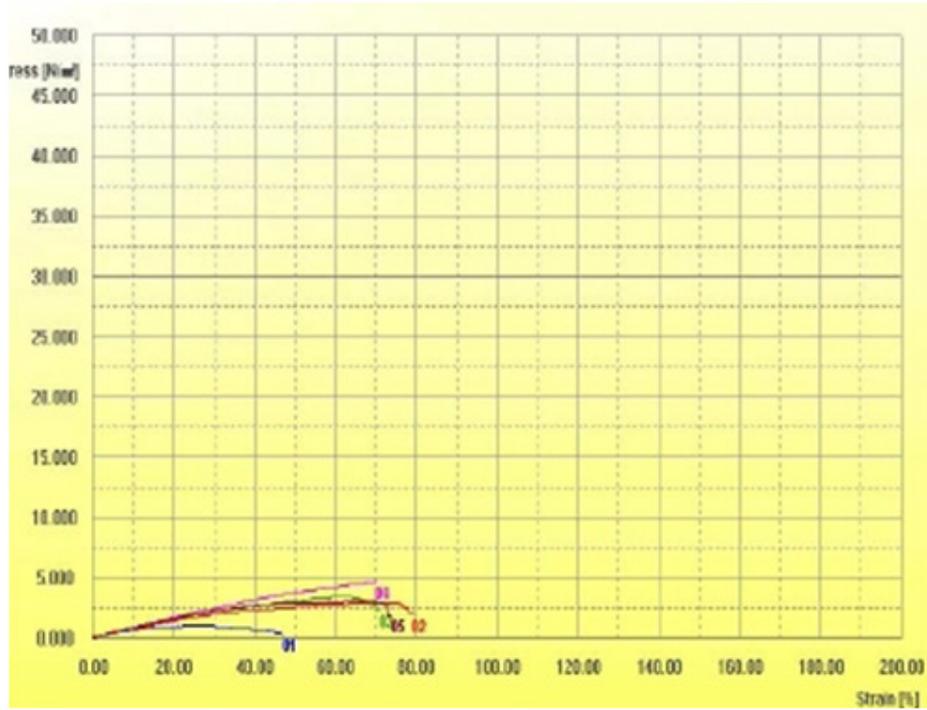
It takes about 2 ~ 3 hours to completely cure the epoxy-based adhesive, but the acrylic-based adhesive can be cured in about 10 ~ 15 minutes. Epoxy-based adhesives are hardly influenced by curing temperature, but the acrylic-based adhesives are relatively less affected by curing temperature. The acrylic-based adhesives can be rapidly cured even at room temperature.

Especially, Methyl Methacrylate Adhesives, MMA, acrylic adhesives have adhesive properties that are comparable to those of epoxy adhesives and it has even more advantages such as a fast curing rate and it is not significantly affected by surface treatment of target materials before bonding.

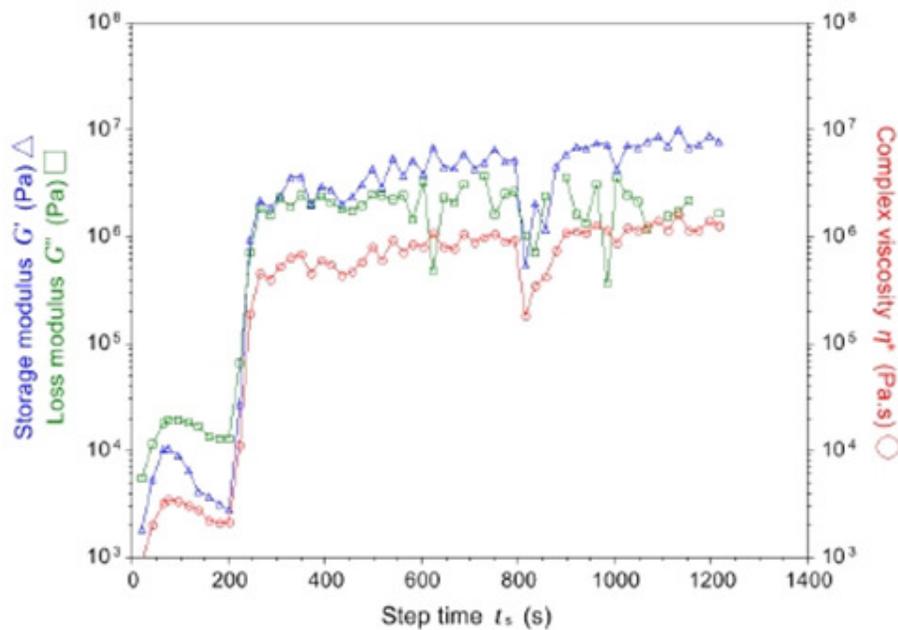
The adhesive strength of epoxy-based adhesives may greatly differ depending on the surface treatment method on target materials before bonding. However, the MMA acrylic adhesive exhibits comparatively higher adhesive strength regardless of the surface treatment method.

The adhesive strength varies depending on the kind of the target materials. For example, acrylic adhesives show higher adhesion strength to acrylic materials than Polycarbonate. However, the MMA acrylic adhesives are less affected by kind of target materials than general acrylic adhesives and it exhibits higher adhesive strength in general cases.

We measured the tensile shear bonding strength of the MMA acrylic adhesive. Figure 1 shows the graph of the measured data. The test speed was 1.3 mm/min and the bonding area was 25x25 mm<sup>2</sup>. Five samples were measured, and the deviation between the samples was measured to a large extent. The adhesive was attached to the metal substrate using a dispenser, and the tensile shear bonding strength was measured after 1 hour. As a result of the calculation, the horseshoe bonding strength was expected to be about 3 N/mm<sup>2</sup>, which is converted to 30.6 kgf/cm<sup>2</sup>. The measured values were in the range of 1 ~ 5 N/mm<sup>2</sup>.



**Figure 1.** Tensile shear bonding strength of MMA acrylic adhesive. Graph shows the measured data of 5 specimens.



**Figure 2.** Curing time of MMA acrylic adhesive which was measured using a rotating rheometer.

The horseshoe bonding time is the time for the adhesive to be cured. The curing time was measured using a rotating rheometer. The test results showed that adhesive curing is completed in less than 300 seconds. As shown in the figure 2, the storage modulus reached  $10^6$  Pa in about 200 seconds, the loss modulus reached about  $5 \times 10^5$  Pa, and the complex



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viscosity reached about  $1 \times 10^5$  Pa. The reduced adhesive curing time, in other words, reduces the time for replacing horseshoe. By reducing the replacement time, horse would feel comfort and it can reduce the risk of injury of farrier. Also, it is expected that not very well skilled people are able to replace the horseshoe by them.

Figure 3 shows the application of MMA acrylic adhesive on the back of horseshoe and figure 4 shows the hoof fitted with a horseshoe with MMA acrylic adhesive.



**Figure 3.** Application of MMA acrylic adhesive on the back of horseshoe.



**Figure 4.** Hoof fitted with a horseshoe with MMA acrylic adhesive.

Figure 5 shows a photo of horseshoe removal process. The removal was carried out by mechanical force, but it is anticipated that the removal time will be shortened when the chemical is used in the future. After removing the horseshoes, the hooves were observed and it was confirmed to be free from wounds because no nail was used.





**Figure 5** A photo of horseshoe removal process.

### 3. CONCLUSION

In this study, we suggested the method of mounting horseshoe on horse hoof using adhesives. If we can mount the horseshoe using adhesive, the mounting process can be much simpler, and, therefore, the processing time can be much shortened and the risk of injuries of farrier can be much reduced. We suggested the certain adhesive which is suitable for the horseshoe mounting, and the properties of the adhesive were measured and presented. The Methyl Methacrylate Adhesive showed good properties compared to other types of adhesives such as a fast curing rate and bonding strength. The tensile shear bonding strength of the Methyl Methacrylate Adhesive was measured as  $\sim 3 \text{ N/mm}^2$ . The curing time of the adhesive was measured as less than 300 seconds. The storage modulus of the adhesive reached  $10^6 \text{ Pa}$ , the loss modulus reached about  $5 \times 10^5 \text{ Pa}$ , and the complex viscosity reached about  $1 \times 10^5 \text{ Pa}$  in 200 seconds.

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