

## The Effect of the pH Value of Wood on the Curing Reaction of Low Toxic Urea-Formaldehyde Resin

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**Abstract:** The differential scanning calorimetry(DSC) was used to study the curing reaction of low toxic UF resin with poplar, birch, larch powder in different pH value. The results showed that the effect of different wood flour and its pH value on the curing reaction of UF resin was not the same. Along with the increase of the pH, the peak temperature and the onset temperature was raised; the peak temperature and the onset temperature of poplar was higher than that of the birch. The temperature of the curing reaction of UF resin modified by melamine was higher than the UF resin without modification.

### Introduction

The realization of acid-base properties and buffer capacity of wood-based panel materials is of great significance to determine the scope of its application. The pH value of wood and buffer capacity serves as important factors having impact on the binding of wood and finishing of products. The pH value of wood itself can change the pH value of adhesive and coating at interface, and change their curing process. The urea-formaldehyde resin, frequently applied in wood-based panel, usually can not realize the optimal curing effect under the condition of acid deficiency. Therefore, the realization of pH value and buffer capacity of various raw materials is the key condition for the formulation of binding process and improvement of binding strength. This thesis, through the adjustment of pH values of wood and the utilization of DSC, researches on the impact of different pH values on the low toxicity urea formaldehyde resin curing reaction.

### Experimental

**Materials.** The molar ratios of unmodified urea-formaldehyde resin are 1.05:1, 1.10:1, 1.15:1 respectively, the molar ratios of urea-formaldehyde resin modified by melamine are 1.05:1, 1.10:1, 1.15:1. JQ-22 stands for melamine modified urea-formaldehyde resin, JQ-21 stands for unmodified urea-formaldehyde resin.

**Differential Scanning Calorimetry (DSC).** DSC measurements were performed with the thermal flow type DSC-204 manufactured by NETZSCH Company, Germany. The heating rate of samples in each group was 3°C/min, the initial temperature was 30~40°C, the final temperature was 200°C.

### Results and Discussion

**Curing reaction between urea-formaldehyde resin having molar ratio of 1.05 with wood powder having different pH values.** The results of curing reaction tested through the application of DSC were shown in table 1,2 and 3.

**Table 1. Curing reaction parameters between poplar powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	114.6	124.4	124.5	124.6	128.3
Starting point (°C)	88.9	94.3	95.0	95.7	97.2
Ending point (°C)	138.9	150.8	150.3	149.2	148.9

**Table 2. Curing reaction parameters between birch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	109.5	114.2	116.2	117.8	125.2
Starting point (°C)	76.9	88.5	91.5	94.6	95.2
Ending point (°C)	141.5	143.1	151.1	144.3	148.3

**Table 3. Curing reaction parameters between larch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	108.5	119.8	123.1	124.7	132.7
Starting point (°C)	84.2	92.7	93.2	94.4	100.7
Ending point (°C)	140.4	148.9	153.2	148.9	154.0

It can be found out from the above results that the peak value and the starting point gradually increased and present obviously changed with the uplift of poplar wood powder pH value under the conditions of same heating rate and the same kind of adhesive. As the pH value of poplar itself was 6.28, little changed present when the pH values were 5, 6 and 7, the peak value and the starting point of birch wood powder and larch wood powder gradually increased and present obviously changed with the uplift of pH values.

At the same pH values, the peak value and the starting point emerging in the curing reaction between poplar and urea-formaldehyde resin are uniformly higher than that of birch wood powder. When pH was 8, the peak temperature and the starting point temperature emerging in the curing reaction between larch and resin were higher than that of other two kinds of wood powders; When pH was less than 8, the peak temperature and the starting point temperature emerging in the curing reaction between larch and resin present no regular pattern if compared with other two kinds. It can be seen from the above phenomena that the peak temperature and the starting point temperature will be high if the pH value of wood itself was high.

**Curing reaction between urea-formaldehyde resin having molar ratio of 1.10 with wood powder having different pH values.** The results of curing reaction tested through the application of DSC were shown in table 4, 5 and 6.

**Table 4. Curing reaction parameters between poplar powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	116.0	124.8	126.3	129.9	130.4
Starting point (°C)	88.9	95.1	97.6	97.7	99.3
Ending point (°C)	142.3	147.2	150.8	155.0	154.1

**Table 5. Curing reaction parameters between birch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	109.9	116.3	124.0	126.8	126.2
Starting point (°C)	84.3	88.4	93.6	96.5	99.6
Ending point (°C)	146.5	146.0	148	150.7	156.4

**Table 6. Curing reaction parameters between larch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	111.1	117.5	125.2	127.9	134.0
Starting point (°C)	82.8	90.8	96.4	98.1	104.9
Ending point (°C)	145.8	127.0	151.4	148.8	152.9

At the same pH values, the peak value and the starting point emerging in the curing reaction between poplar and urea-formaldehyde resin are uniformly higher than that of birch wood powder. The peak temperature emerging in the curing reaction between larch wood powder and resin is uniformly higher than that of birch wood powder. When pH = 8, the peak temperature and the starting point temperature emerging in the curing reaction between larch wood powder and resin are uniformly higher than that of other two kinds of wood powders; The larch wood powder presents no obvious regular pattern if compared with poplar wood powder.

**Curing reaction between urea-formaldehyde resin having mol ratio of 1.15 with wood powder having different pH values.** The results of curing reaction tested through the application of DSC were shown in table 7, 8 and 9.

**Table 7. Curing reaction parameters between poplar powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	111.0	122.6	127.0	130.7	132.2
Starting point (°C)	85.6	93.6	98.6	101.0	101.7
Ending point (°C)	141.0	144.6	147.5	152.2	150.7

**Table 8. Curing reaction parameters between birch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	101.6	113.7	124.4	124.2	127.6
Starting point (°C)	82.8	89.7	95.2	98.1	98.6
Ending point (°C)	128.5	142.8	153.4	148.9	151.3

**Table 9. Curing reaction parameters between larch powder having different pH values with UF resin**

pH value	pH=4	pH=5	pH=6	pH=7	pH=8
Peak value (°C)	107.3	121.8	126.6	128.8	135.6
Starting point (°C)	84.6	96.7	98.0	98.3	106.5
Ending point (°C)	137.8	147.5	131.7	152.6	153.9

The peak temperature and starting point temperature emerging in the curing reaction between poplar wood powder and urea-formaldehyde resin is uniformly higher than that of birch wood powder. The peak temperature emerging in the curing reaction between larch wood powder and resin is uniformly higher than that of birch wood powder. When pH = 8, the peak temperature and the starting point temperature emerging in the curing reaction between larch wood powder and resin are uniformly higher than that of other two kinds of wood powders; The larch wood powder presents no obvious regular pattern if compared with poplar wood powder.

**Curing reaction of urea-formaldehyde resin having different molar ratios.** The results of UF resin JQ-21, JQ-22 curing reaction having different molar ratios tested through the application of DSC were shown in table 10.

**Table 10. Curing reaction parameters of UF resin**

pH value	JQ-21-1.05	JQ-22-1.05	JQ-21-1.10	JQ-22-1.10	JQ-21-1.15	JQ-22-1.15
Peak value (°C)	129.8	131.8	131.0	133.2	130.8	134.7
Starting point (°C)	96.8	100.4	98.0	106.7	102.8	109.0
Ending point (°C)	148.7	157.7	150.6	152.2	148.6	154.3

It can be found out from the above table that the starting temperature and peak temperature of JQ-22 were higher than that of JQ-21. Since the curing temperature of melamine was higher than that of UF resin. Therefore, the starting temperature and peak temperature of UF resin modified by melamine was uniformly higher than that of unmodified UF resin.

### Conclusions

1) The pH values were diversified depending on different kinds of woods. The pH value of poplar was 6.28, inclining to neutrality; the pH value of birch and larch were 4.9 and 4.8, inclining to acidity.

2) Under the condition of same kind of low toxicity urea-formaldehyde resin, the impact of wood powders having different pH values on urea-formaldehyde resin curing reaction varies. In addition, the peak temperature and the starting temperature emerging in the curing reaction increase with the uplift of pH value.

3) Under the condition of same kind of low toxicity urea-formaldehyde resin, the impact of different wood powders on urea-formaldehyde resin curing reaction varies. Under the condition of same kind of pH values, the peak temperature and the starting temperature emerging in the curing reaction between poplar wood powder and urea-formaldehyde resin were uniformly higher than that of birch for the reason that the pH value of poplar itself was higher than that of birch. As the oil content in larch was relatively high, the regular pattern was not obvious when pH value was less than 8. When pH value equals to 8, the peak temperature and the starting temperature were uniformly higher than that of other kinds of wood powders.

4) The starting temperature and peak value of JQ-22 were uniformly higher than that of JQ-21. As the activation energy of melamine reaction was relatively high, the curing temperature of JQ-22 was higher than the unmodified urea-formaldehyde resin JQ-21.

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