# Lauric Acid/Wood Fiber Blends for Shape Stable Phase Change Material

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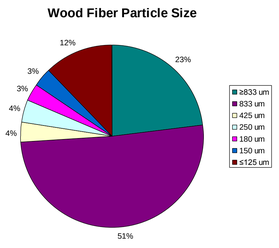
## Introduction

Energy saving, a major issue today, is one of the main components in green building systems which can be achieved by using phase change materials (PCM) as energy storage in buildings. Fatty acids have greater properties over other PCMs because of its: (1) high capacity of latent heat for thermal energy storage, (2) suitable melt and crystallization temperatures ($T_m$, $T_c$), (3) potential for sustainable production, (4) non toxic and non-corrosive properties. However, the low melt viscosity of fatty acids present challenges in retaining shape at temperatures greater than its melting temperature. In this project, lauric acid (LA) is as a matrix in preparing wood fiber (WF) composites. The goal in developing this material is to produce a shape stabilized PCM for use in building products. To understand the effects of processing temperatures and mixing ratios on the thermal properties of the LA/WF blends, the composites were first melt blended in a torque rheometer, and further characterized by thermogravimetric analysis (TGA), differential scanning calorimetry (DSC) and polarized optical microscopy (POM).

## Materials and Methods

### Materials



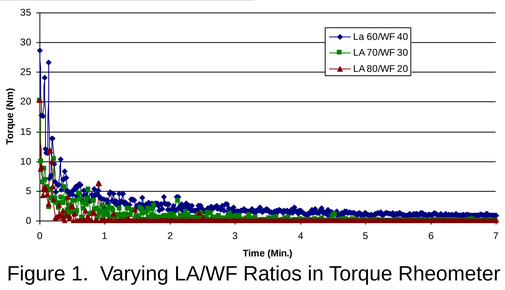

- Purity >99% Lauric Acid (Palmac 99-12, Acidchem International Sdn. Bhd.)
- Thermal mechanical pulp of softwood fiber (Plum Creek)

### Method

- Wood fiber (WF) was oven dried with a 2.73% moisture content
- Lauric acid (LA) and WF mixtures were prepared in 60/40, 70/30, and 80/20 (wt %) ratios, respectively
- Mixtures of LA/WF were melt blended in a torque rheometer with 50, 60 ,80, 100ºC processing temperatures
- The thermal properties of the blends were analyzed by differential scanning calorimetry (DSC) and thermogravimetric analyses (TGA)
- The morphology properties of the LA/WF blends were analyzed by the polarized optical microscope (POM)

## Results and Discussions

### Torque Rheometer




- More WF, the higher melting torque occurred (comparing after 3 mins. blended

Figure 1. Varying LA/WF Ratios in Torque Rheometer

- No effect with varying processing temperature (comparing after 3 minutes blending

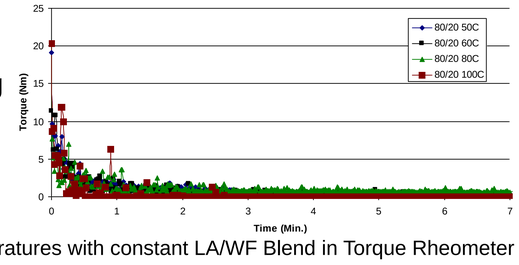
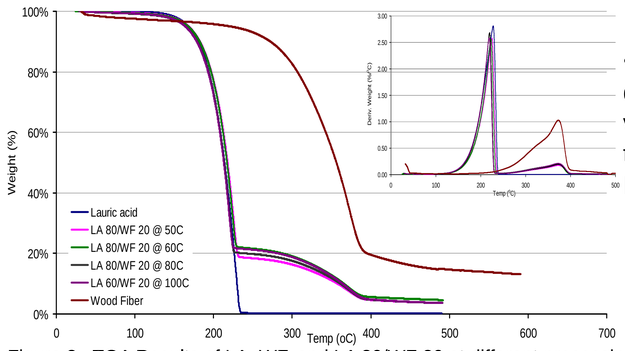



Figure 2. Varying Temperatures with constant LA/WF Blend in Torque Rheometer

### Thermogravimetric analysis (TGA)




- No effect on the degradation with varying processing temperatures of the LA/WF blends

Figure 3. TGA Results of LA, WF, and LA 80/WF 20 at different processing temperatures

- WF did not influence the degradation of LA in the blends system
- LA and WF all thermal degraded at c.a. 210 and 380ºC

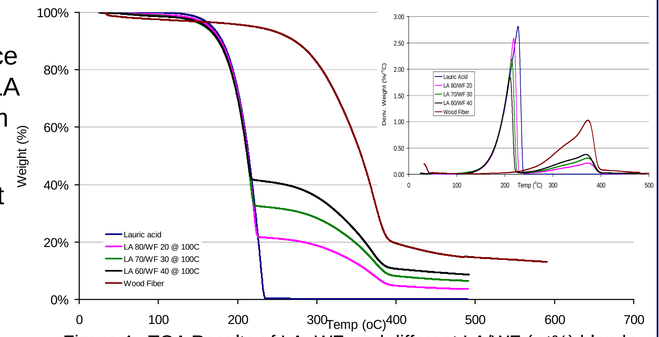
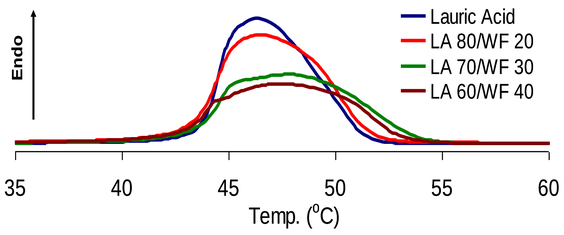



Figure 4. TGA Results of LA, WF, and different LA/WF (wt%) blends

### Differential Scanning Calorimetry (DSC)




WF content increased:

- No effect on $T_m$
- Wider range of energy absorbing temperatures

Figure 5. DSC curves of pure lauric acid and various LA/WF (wt %) ratio blends

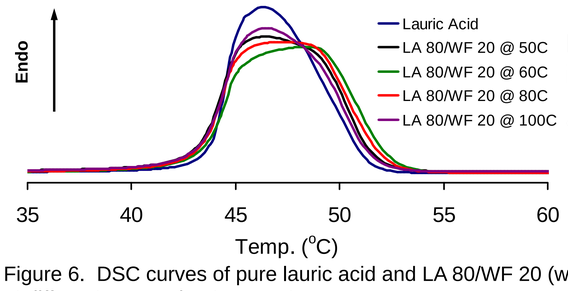
WF content increases:

- Both of the $\Delta H_m$ and $\Delta H_c$ decreased
- $T_c$ slightly reduced

| LA/WF. | $T_m$ (ºC) | $\Delta H_m$ (J/g) | $T_c$ (ºC) | $\Delta H_c$ (J/g) |
|---|---|---|---|---|
| Control* | 47.0 | 198.7 | 41.5 | 209.4 |
| 80:20 | 47.4 | 184.0 | 40.6 | 196.8 |
| 70:30 | 48.2 | 169.3 | 38.7 | 186.2 |
| 60:40 | 47.6 | 168.7 | 39.2 | 185.9 |

*Virgin Lauric Acid

Table 1. Thermal properties of the varying ratio blends at 100ºC




Processing temperatures increased:

- No effect on $T_m$ and $T^c$

Figure 6. DSC curves of pure lauric acid and LA 80/WF 20 (wt%) at different processing temperatures.

Processed temps. Increased :

- Slightly reduced the $\Delta H_m$ and $\Delta H_c$

| Process Temp. | $T_m$ (ºC) | $\Delta H_m$ (J/g) | $T_c$ (ºC) | $\Delta H_c$ (J/g) |
|---|---|---|---|---|
| Control* | 47.0 | 198.7 | 41.5 | 209.4 |
| 50ºC | 47.6 | 195.0 | 41.0 | 208.7 |
| 60ºC | 47.8 | 179.0 | 40.8 | 191.3 |
| 80ºC | 47.9 | 186.5 | 40.6 | 199.8 |
| 100ºC | 47.4 | 184.1 | 40.5 | 196.8 |

*Virgin Lauric Acid

Table 2. Thermal properties of varying the processing temperatures of the LA80/WF20 (wt%)

### Polarized Optical Microscope (POM)

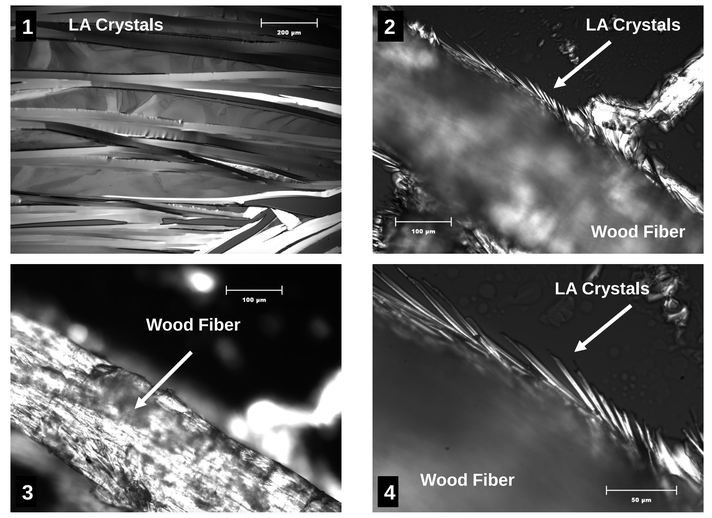



Figure 7. POM photos of (1) pure lauric acid at room temperature; (2), (3), (4) LA80/WF20 (wt%) blend at room temperature

- WF absorbed molten lauric acid during the melt mixing
- LA crystallized along the wood fiber direction with an angle) appeared only bottom of the WF, not surface of WF)
- The crystals may indicate that the lauric acid was melt flew out from wood fiber (during heating), and further crystallized after temperature below $T_c$

## Conclusion

- Analyzed results showed that the LA/WF blends can still maintain the thermal properties as the requirements of phase change materials for thermal energy storage.
- WF absorbed molten LA (LA penetrated into WF) as function of stabilizing the phase change material.
- The thermal analysis and morphology results indicated that not enough evidence can prove if any interaction between lauric acid and the wood fiber.

## Future Work

- Evaluating the shape stable stability of hot-pressed sample by heat deflection temperature test
- Grafting lauric acid onto wood fiber for improving the stability and thermal properties

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