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Evaluation of Wood Plastic Composite Prepared fromMahogany Wood Dust/polyethylene

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ABSTRACT
The preparation and mechanical behavior of wood plastic composite materials fabricated with Mahogany wood particle dust/ polyethylene matrix on stability and durability of various composite formulations was investigated. Low water absorption was observed in composite made from virgin high density polyethylene film which decreased from 35.7 to 4% after 2 h and 65.5 to 7.3% after 24 h water immersion. Composite made from waste high density polyethylene film decreases from 34.5 to 3.6% and 59.8 to 4.6% after 2 h and 24 h water immersion. Ignition time showed increase as the wood dust particle increased (0.65 to 0.22 mm/s) for the virgin high density polyethylene composite and (0.73 to 0.33 mm/s) for waste high density polyethylene composite. Flammability test shows that ignition time increased as the polymer resin content increases (0.65 to 0.09mm/s) for the virgin high density polyethylene composite and (0.8 to 20.8 MPa) for waste high density polyethylene film base composite SEM show pronounced deformation of the polymer matrix and significant reduction in fiber pull-out, indicating the compatibilizer likely affects interface, reducing interfacial tension and improving adhesion.

Keywords: Polyethylene, Mahogany, composite, Absorption, wood, dust

I. INTRODUCTION

The amount of garbage or waste is increasing day by day as the world's population increases [1,8]. If we see closely, most of the wastes are from the things that we used daily such as plastic and paper. Due to the increasing number of mankind in the world, more products have to be manufactured to cater the needs of every human being [2]. These cause natural resources such as wood and petroleum to deplete fast. Realizing this, recycling is introduced as a way to curb the problems that arise. By recycling natural resources can be preserved for future use and in the same time protect the environment such as forest that gives oxygen for human to life. Recycling also reduces amount of waste produce and can help to encounter garbage accumulation problem [3]. Recycling also reduces cost since manufacturing product from raw material to finished product is getting expensive as time passes [2,3]. To overcome this problem, this study is to develop composite from recycled material such as wood flour (saw dust) and polyethylene film (package water bag). From this combination of wood flour and plastic, it is known as Wood Plastic Composite (WPC). By doing this research, a deeper study on the properties of WPCs can be done in order to develop and improve the usage of this composite in the future.

II. MATERIALS AND METHODS

2.1 Apparatus and reagents

Conical flask, beaker, measuring cylinder, stirrer, weighing balance, spatula, funnel, test tubes, water, toluene, polyethylene (package water bag), saw dust, oil bath, aluminum mold and thermometer

2.2 Wood plastic composite preparation

Wood dust was dried in an oven at 100 ℃ for 24 h to remove moisture and cooled wood dust ground to give fine powdered particles after sieving for easy dispersion in the formulation. For all the formulations prepared, toluene was measured into a conical flask and was mixed with a certain gram of the resin. The mixture was prepared at temperature of 135^0C in an oil bath till the resin dissolved totally in the solvent. Saw dust was measured and added to the solvent-resin mixture and stirred continuously for at least five (5) min at same temperature the mixture was then cast in an aluminum mold with 3 m thickness, 7 m width and 10 m length [4,5]. The composite was made conditioned at a temperature of 23±2°C and relative humidity (RH) of 50±5% for at least 40 h according to ASTM D618-99.

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2.3 Water absorption (ASTM D 570-98)

Water absorption test was performed following the ASTM D 570-98 method. Water absorption of the composites was determined after 2 h and 24 h by immersion in distilled water at room temperature, 24°C. Five specimens of each formulation were dried in an oven for 24 h. The dried specimens were weighed with a precision of 0.001 g. All specimens were immersed in distilled water. At the end of the immersion periods, the specimens were removed from the distilled water, the surface water was wiped off using tissue, and wet weight values were determined. Water absorption percent was calculated using the following formula [7].

$M(\%) = (m_t - m_o)/m_o \times 100$,

Where m_o and m_t denote the oven-dry weight and weight after time t, respectively.

2.4 Flammability Test (ASTM D635)

A 60 mm mark was measured and marked out on each of the specimen. The specimen was then clamped horizontal in a retort stand with the marked 60 mm distance protruding out of the clamp. The free end of the sample was ignited and the time taken for the sample to ignite was recorded as the ignition time (I_t). The sample was allowed to burn to 60 mm mark (D_p). The relative rates of burning for the different samples were determined using the expression [2] stated below:

Flame propagation rate (mm/s) = $D_p(mm)/P_t(sec)$-$I_t(sec)$

Where D_p = Propagation distance measured in mm,

P_t= Flame propagation time measured in seconds

I_t = Ignition time measured in seconds.

2.5Hardness Test (ASTM D-2240)

Hardness is refer to the resistance of a material to indentation, the higher this resistance the harder the material and vice-versa. The hardness test was carried out using Modified Meyer hardness tester. The hardness for the samples was determined using the expression stated bellow [10].

$$BHN = \frac{F}{\pi(D - \sqrt{D^2 - D_i^2})}$$

Where

F = The imposed load

D = Diameter of the indenter

D_i = Diameter of the indentation

2.6 Scanning Electron Microscopy (SEM) (ASTM E9862-97)

A morphology study was carried out using scanning electron microscopy (SEM) to evaluate the fractured surface of samples. The changes in morphology are important to predict fiber interaction with the matrix in composites [8].

III. RESULTS AND DISCUSION

3.1 Water absorption

Figure 1 shows the water absorption of virgin and waste high density polyethylene/Mahogany wood dust particle composite at constant polyethylene. High water absorption was observed in composite made from waste high density polyethylene film which varied from 35.7 to 123.1% after 2 h and 65.5 to 155.4% after 24 h water immersion. Composite made from virgin high density polyethylene film varied from 34.5 to 91.4% and 59.8 to 147.6% after 2 h and 24 h water immersion respectively.

Figure 2 shows the water absorption of virgin and waste high density polyethylene/Mahogany wood dust particle composite at constant sawdust. Low water absorption was observed in composite made from virgin high density polyethylene film which decreased from 35.7 to 4% after 2 h and 65.5 to 7.3% after 24 h water immersion. Composite made from waste high density polyethylene film decreases from 34.5 to 3.6% and 59.8 to 4.6% after 2 h and 24 h water immersion.

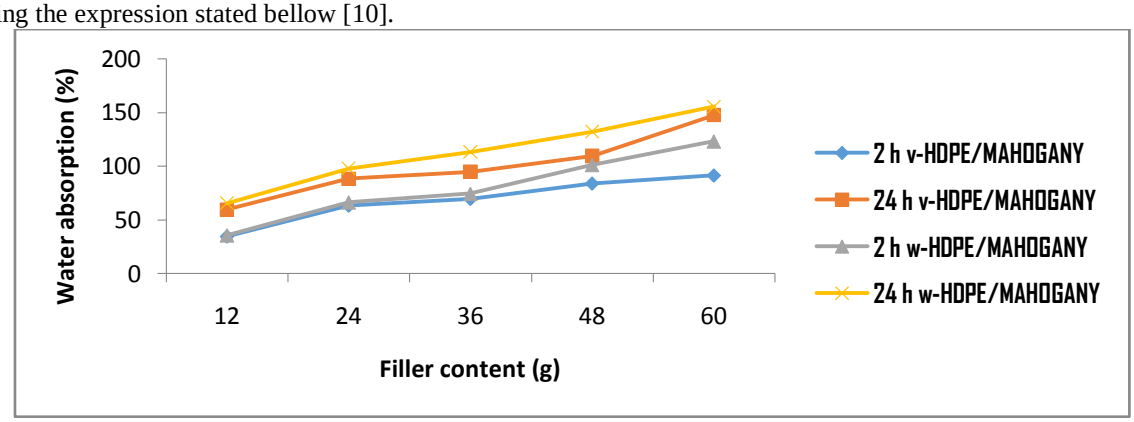

Figure 1: Effect of filler content on Water absorption of Mahogany wood flour with virgin and waste high density polyethylene based composites at constant polyethylene after 2 and 24 h water immersion.

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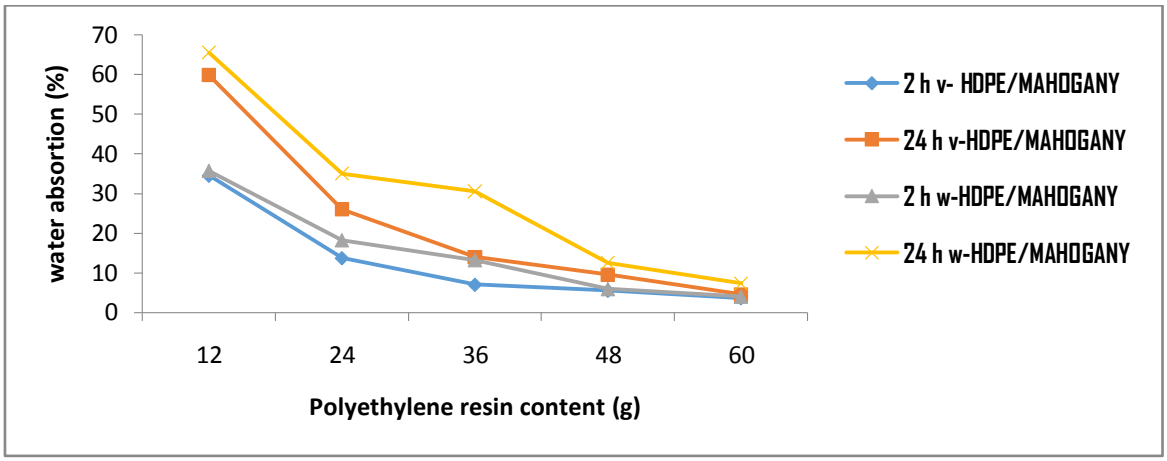

Figure 2: Effect of resin content on water absorption of Mahogany wood flour with virgin and waste high density polyethylene based composites at constant sawdust after 2 and 24 h water immersion

3.2 Flammability

Figure 3 shows the flammability of virgin and waste high density polyethylene/mahogany wood dust particle composite at constant polyethylene film. Ignition time increases as the wood dust particle increased which make the flame propagation rate of the composite to decrease from (0.65 to 0.22 mm/s) for the virgin high density polyethylene composite and (0.73 to 0.33 mm/s) for waste high density polyethylene composite.

Figure 4 shows the flammability of virgin and waste high density polyethylene/Mahogany wood dust particle composite at constant sawdust. Ignition time increased as the polymer resin content increases which make the flame propagation rate of the composite to decrease from (0.65 to 0.09mm/s) for the virgin high density polyethylene composite and (0.73 to 0.15mm/s) for waste high density polyethylene composite.

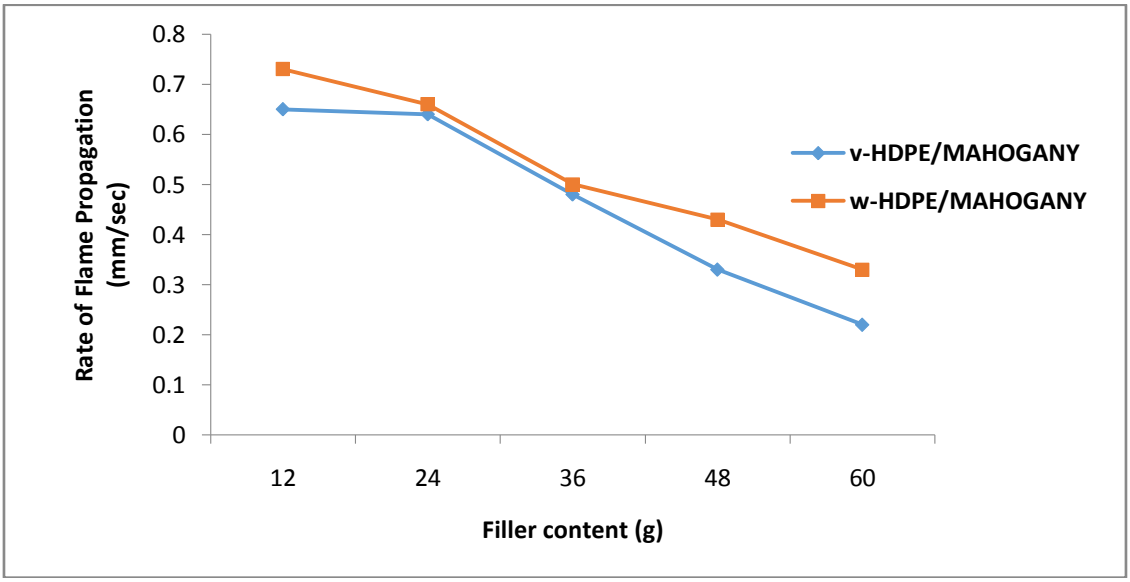

Figure 3: Effect of filler content on rate of flame propagation of Mahogany wood particle with virgin and waste high density polyethylene film based composites at constant polyethylene.

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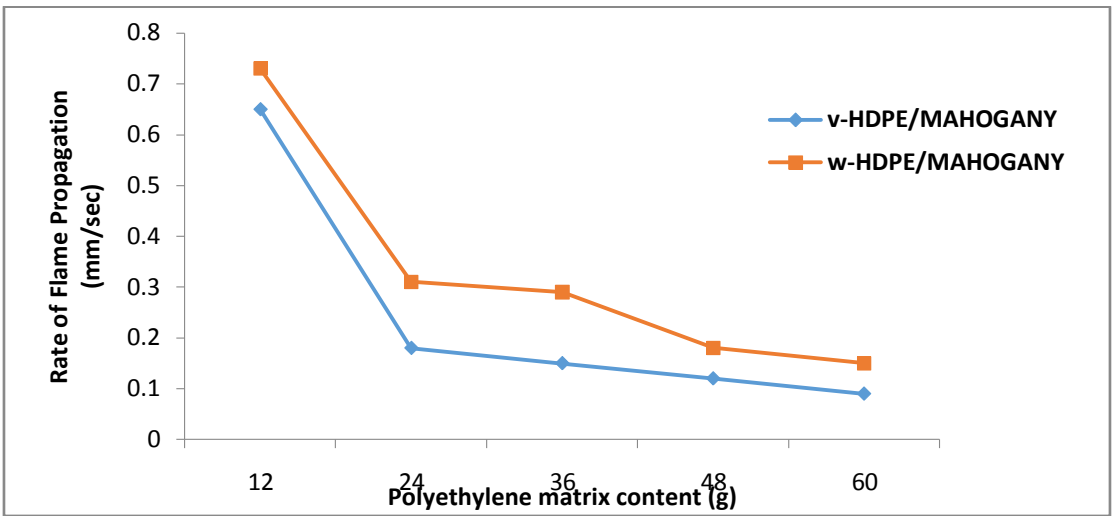

Figure 4: Effect of resin content on rate of flame propagation of Mahogany wood particle with virgin and waste high density polyethylene film based composites at constant sawdust.

3.3 Hardness test

Figure 5 and figure 6 show the hardness of virgin and waste high density polyethylene/Mahogany wood particle dust at constant polyethylene film and at constant sawdust respectively. At constant polyethylene the hardness decreased as the fibre increased from (81.6 to 28 MPa) for virgin high density polyethylene film base composite and (68.8 to 20.8 MPa) for waste high density polyethylene film base composite the virgin high density polyethylene composite is harder than the waste high density polyethylene composite. While at constant sawdust hardness increases as the polymer resin increases from (81.6 to 445.8 MPa) for virgin high density polyethylene film and (68.8 to 363.6 MPa) it also recorded high hardness in virgin high density polyethylene composite than in waste high density polyethylene composite.

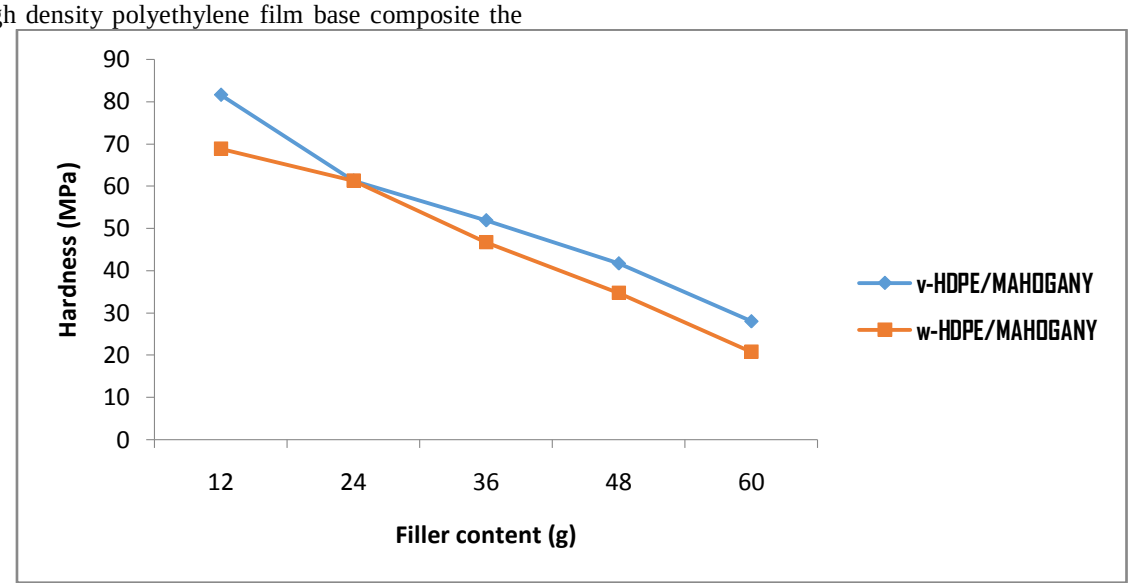

Figure 5: Effect of filler content on hardness of Mahogany wood particle with virgin and waste high density polyethylene film based composites at constant polyethylene.

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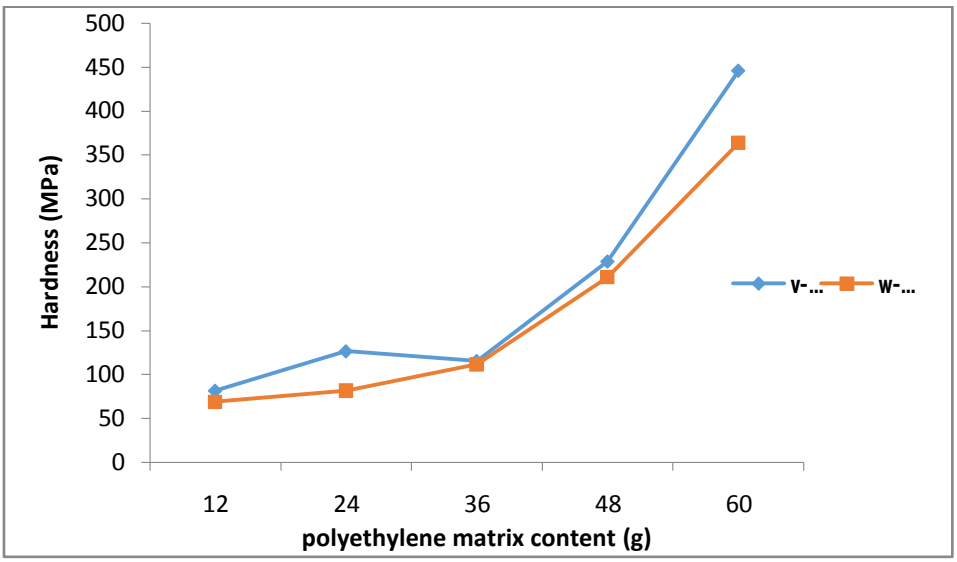
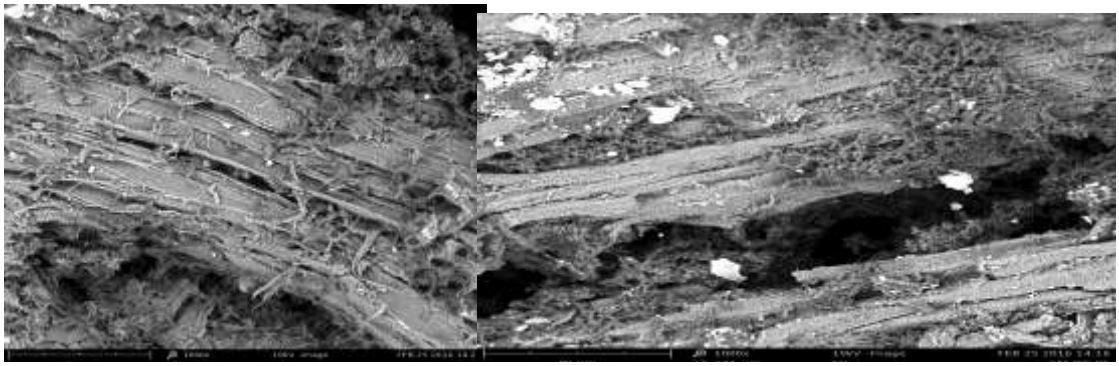


Figure 6: Effect of resin content on hardness of Mahogany wood particle with virgin and waste high density polyethylene film based composites at constant sawdust.

Scanning Electron Microscope

Figures 7 (a) virgin high density polyethylene 12 g / mahogany 24 g composite. (b) waste high density polyethylene 24 g/mahogany 12 g composite, show pronounced deformation of the polymer matrix and significant reduction in fiber pull-out, indicating the compatibilizer likely affects interface, reducing interfacial tension and improving adhesion. The dispersion of the wood fibres in the waste high density polyethylene/mahogany composite (Fig. 8 (c)) is uniform as compared to waste high density polyethylene/mahogany composite (Fig. 8 (d)). This may be due to the different grade of plastic and other impurities in the waste high density polyethylene. In some cases, the part of the wood lumen was filled with plastic that could increase the strength of the composites because of mechanical interlocking.



(a) (b)

Figure 7 SEM images (×1000) of (a) vHDPE 12 g/ Mahogany 24 g, composite. (b) wHDPE 12 g/Mahogany 24 g composite.

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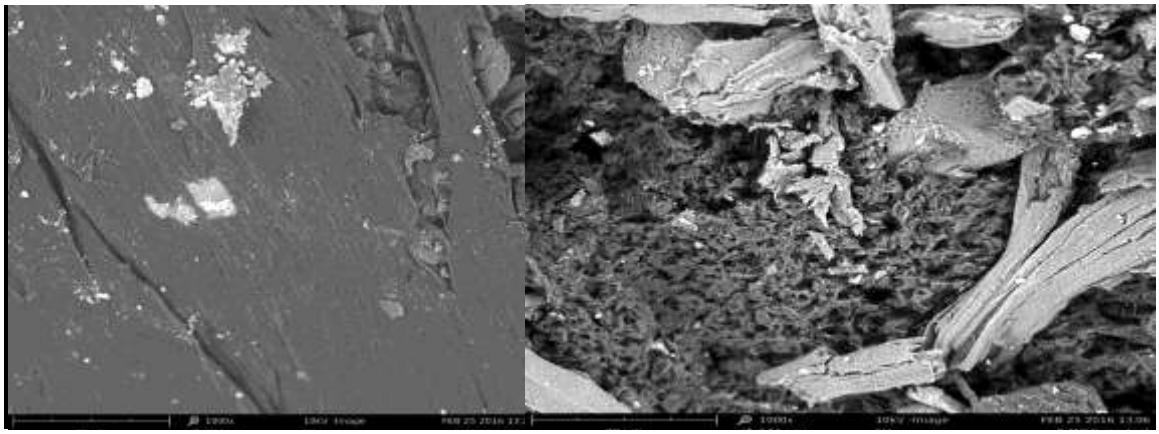

(c) (d)

Figure 8 SEM images (×1000) of (c) vHDPE 24 g / Mahogany 12 g composite (d) wHDPE 24 g / Mahogany 12 g composite.

IV. CONCLUSION:

The processing and desired properties of WPCs can be improved by using additives such as lubricants, coupling agents, antioxidants, UV-absorbers and antimicrobial agents among others. WPCs properties depends on many factors including the species and forms of the wood filler, types and forms of polymer matrix, compatibility and chemical bonding of the

wood fillers and polymer matrix, and processing methods used. The mechanical properties of WPCs depended on the interfacial bonding between the wood fillers and polymer matrix. The wood plastic composite that was produced was used as a notice board after comparing it with the standard of a commercial sample of a notice board.

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