1 INTRODUCTION

1.1 Motivation and statement of problem

With strict laws and policies like Malaysia’s very own National Forestry Act 1984, to protect natural wood from illegal logging and harvesting, it has been difficult for avid natural wood-lover to purchase or satisfy their passion. Hence, wood-composite makes a suitable and the most promising alternative to solve this issue.

Wood-composite is viable in the form of medium-density fibreboard (MDF), particleboard, oriented strand board, plywood, etc. The manufacture of composite wood-based products occurs when various sources of wood particles are bind with a thermosetting binding agent which is usually a type of resin. This will eventually form into compacted mats which are rather loose. These wood-particles are also varied in many different forms. Such examples are like flakes, fibres, strands, and particulate forms. Different wood-particles yield different type of boards. The generic end products are fibreboard, hardboard, flakeboard, strandboard, particleboard, and waterboard to name a few. Unlike hardboard and medium-density fibreboard, these boards are characterised in terms of their density. Back to production or preparation of wood composite, the mats are then placed in mould and pressed until it reaches a suitable or preferred thickness using a hot-press machine. Then, it is left to cool down until the adhesive or resin is cured. (Taylor & Reid, 1984).

The resin which is usually utilised is urea formaldehyde resin. Approximately, urea formaldehyde resin is responsible for at least 90% or more in the world’s wood-composite board production (Maloney, 1993). Moreover, urea formaldehyde is the most popular amino resins (William, 1991). From the amino resins manufacturing in the industry, urea formaldehyde comprises of 80% of the amino resins produced worldwide and the rest belongs to the rest of the amino resin group, primarily melamine-formaldehyde (Conner, 1996). The properties which make urea formaldehyde very much desired in the wood-composite industry as the main adhesive are as follow:
Cheap and low in production cost,
Solubility towards water,
Low curing temperature,
Resistive to abrasion and microorganisms,
Fast reaction time under hot press,
Excellent thermal stability,
Lack of colour, and

Unfortunately, the ultimate drawback for utilising urea formaldehyde in wood-composite is the emission of free formaldehyde to the surrounding. Formaldehyde is labelled as a carcinogenic toward humans, which makes it very much cancerous. The International Agency for Research on Cancer (IARC, Mongraupgh on the evaluation of carcinogenic risk to human, 2006) classified formaldehyde as “carcinogenic to human (Group 1). On top of that, a policy imposed by the California Air Resources Board (CARB) imposes restriction which limits formaldehyde emission. This resulted in greatly on the wood-based panel industry (Costa, et al., Scavengers for achieving zero formaldehyde emission of wood-based panels, 2013).

Hence, to overcome this major issue, many research have been done to reduce or eliminate if all, the emission of urea formaldehyde. Some methods which are currently being research and practiced in the industry are reduction of formaldehyde to urea (F/U) ratio, substitution of urea formaldehyde resin, and usage of urea formaldehyde scavengers (Costa, et al., 2013).

1.1.1 Reduction in formaldehyde to urea (F/U) ratio

Myers has studied on the F/U ratio and concluded the contradicting standards set by respective responsible agencies in different countries do not match up (Myers, 1984).

- F/U < 1.2 or < 1.1 to meet German standard
- F/U < 1.3 or < 1.22 to meet NPA emission standards for U.S. mobile homes
- F/U ≥ 1.2 for bending strength and modulus of rupture
- F/U $\geq 1.1$ or possibly $\geq 1.2$ for internal bond
- F/U $\geq 1.2$ or $\geq 1.3$ for 24-hours thickness swell.

Eventually, based on Myers extensive study, he found out that the bending strength and modulus of rupture was thoroughly affected when the F/U dropped to 1.2. Internal bond however, are at an acceptable manner but started deteriorating when the F/U ratio increase to 1.4 or 1.5. Besides that, the thickness swell begins rapidly as F/U falls to 1.3 onwards. Most importantly, the reactivity of urea formaldehyde decreases as the F/U ratio reduces.

### 1.1.2 Substitution of Urea Formaldehyde

Substitution of urea formaldehyde adhesive with a formaldehyde-free compound could be very promising. Unfortunately, due its higher price and lower reactivity, industrial producers are not convinced (Amazio, et al., 2011). A research done (Despres, et al., 2010) suggested that substituting dangerous urea formaldehyde with alternative, non-toxic, non-volatile aldehydes to produce urea-based resins. Unfortunately, these aldehydes have a significant problem, it is coloured (Pizzi, 1983). Besides that, they are also toxic to some level and are have reactivity issues with other compounds present in the binding agent (Mansouri & Pizzi, 2006) (Wang & Pizzi, 1997).

### 1.1.3 Usage of urea formaldehyde scavengers

Usages of urea formaldehyde scavengers are relatively new in the industry. Scavengers are compound utilized to extract or remove a certain substance by either reacting with it or being adsorbing it. Many researches have been done to signify the gain in benefits by using scavengers to reduce urea formaldehyde emission. The usage of natural or biological-based urea formaldehyde scavengers is very common in the industry to reduce urea formaldehyde emission (Kim, et al., 2006). Studies have shown that scavengers like sodium metabisulfite ($\text{Na}_2\text{S}_2\text{O}_5$) is very efficient in particleboards produced with urea formaldehyde and melamine-formaldehyde (MF) resin and yielded successful results (Costa, et al., 2012).