Title	Utilization of palm oil mill wastes in the production of natural rubber antioxidant
Author	Miss Melissa B. Agustin
Degree of	Master of Science in Applied Chemistry
Advisory Committee Chairperson	Associate Professor Dr. Weerachai Phutdhawong

ABSTRACT

The increasing production of wastes from the fast-growing palm oil industry in Thailand calls for the development of new waste management strategies before its negative impact prevails. To address this issue and, in turn, to give added value to palm oil mill wastes, this study was conducted. The main objective of the study was to investigate the feasibility of using palm oil mill wastes which include the oil palm kernel meal (OPKM) and the palm oil mill effluent (POME), as raw materials for the production of natural rubber (NR) antioxidant.

The possible antioxidant from OPKM was isolated using the ash-anthraquinone pulping process which involved alkaline digestion, removal of polysaccharide degradation products, and precipitation at pH 2. Electrocoagulation followed by subsequent recovery of the electrocoagulated compounds from the coagulum through acid dissolution and solvent extraction was employed to isolate the possible antioxidant from POME. The average yield of the potential antioxidant from the OPKM and POME were 4.1g/100g and 17.1g/L, respectively. Preliminary test on the antioxidant activity of the isolates using the DPPH radical scavenging assay showed strong antioxidant activity for OPKM lignin and weak antioxidant activity for the POME isolate when compared to vitamin E.

Partial structural characterization of the potential antioxidants was conducted using UV-Vis, FTIR, ^{13}C-NMR, GC-MS, LCMS and degradation or derivatization experiments. Results showed that the OPKM lignin has a total phenolic (TP) content of 158 mg gallic acid equivalent per gram OPKM lignin and contains the hydroxyl, methoxyl, carbonyl, aromatic, and alkyl groups. Syringyl units followed by the guiacyl units were the dominant monomers as determined through nitrobenzene oxidation. The molecular weights of the components in an alkaline solution have a range of 200-800 amu. For the POME isolate, characterization studies revealed a lower TP content (27 mg gallic acid equivalent per gram POME isolate) and the presence of hydroxyl,

carbonyl, aromatic and alkyl groups. The POME isolate also has a larger content of long chain of saturated C-atoms relative to unsaturated and aromatic C-atoms based on the ^{13}C-NMR spectrum, which was confirmed also by the abundance of long chain-fatty acids and sugar derivatives in the acetylation products. The molecular weights of the individual components range from 300-800 amu.

The isolated antioxidants were used in the preparation of vulcanized natural rubber (NR). Two types of rubber were prepared: the vulcanized NR from STR 5L and the NR latex films. The concentrations of antioxidants were varied from 1 to 3 parts per hundred of rubber (phr) and the properties of the rubber produced before and after accelerated thermal ageing were evaluated and compared to those treated with commercial antioxidants.

The vulcanized NR from STR 5L before thermal ageing showed better resistance to compressive forces, lower rebound resilience, hardness, and tensile strength, but comparable Modulus 300 and % elongation at break (%EB). Increasing the concentration of antioxidant gave varied effects. The NR latex films before thermal ageing have higher tensile strength, Modulus 300, and %EB than those treated with commercial antioxidant. Increase in the concentration of the POME isolate enhanced the tensile properties. After thermal ageing, hardness and Modulus 300 increased while tensile strength and %EB decreased. Better resistance to thermal ageing was achieved when the concentration of the studied antioxidant was 1 phr for the vulcanized NR from STR 5L, and 3 phr for the vulcanized latex film for both the OPKM lignin and POME isolate.

Swelling experiment was conducted to determine crosslink density. Increase in the concentration of both antioxidants favored chain scission for vulcanized NR from STR 5L as reflected in the decrease of crosslink density, thereby decreased the resistance to accelerated thermal ageing. For vulcanized NR latex films, increase in the concentration of the POME isolate favored crosslinking, thereby increased both the crosslink density and resistance to thermal ageing. The effect of increasing the concentration of OPKM lignin, on the other hand, decreased crosslink density.

The thermal degradation of the vulcanized NR from STR 5L and latex films as monitored by thermogravimetric analysis showed similar degradation patterns to those treated with commercial antioxidants, but provided slightly lower onset temperatures.