Journal of Cleaner Production xxx (2013) 1–8

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Evaluating environmental performance of concentrated latex production in Thailand

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A R T I C L E I N F O

Article history:
Received 15 January 2013
Received in revised form
27 July 2013
Accepted 8 November 2013
Available online xxx

Keywords:
Rubber
Concentrated latex
Life cycle assessment
Reduction options
Thailand

A B S T R A C T

Thailand is currently the world's largest natural rubber producer. To maintain a leadership position of natural rubber producer, it has been challenging for Thai rubber entrepreneurs to seek appropriate measures towards producing environmentally friendly rubber products. The objective of this study is to assess the potential environmental impact of concentrated latex production by partial Life Cycle Assessment (LCA) , and to investigate the effects of the options to reduce the impact. The methodology is based on the ISO 14040 series, taking a "Gate-to-Gate" approach (Partial LCA). The activities taken into account include production of chemicals, production of diesel and electricity, diesel combustion, and wastewater treatment. The functional unit is 1 ton of concentrated latex, and the environmental impacts considered in this study include global warming, acidification, eutrophication, human toxicity, photochemical oxidation, and the total environmental impact. The results indicate that electricity use for centrifugation has the largest share, compared with other activities, in global warming (50%), acidification (58%), and photochemical oxidation (55%). Ammonia use for latex preservation accounts for 37% of human toxicity, whereas use of DAP (Diammonium phosphate) accounts for 46% of eutrophication. Based on these results, the following reduction options are therefore identified: 1) electricity efficiency improvement (by installation of inverters to centrifugal machines); 2) improvement of ammonia preparation and storage (by chilling systems); 3) minimizing the use of DAP (by extending coagulation time); and 4) substitution of diesel by LPG. These four options were technically and practically feasible for concentrated latex production, and result in reductions of the total environmental impact by 12%, 8%, 3%, and 5%, respectively.

1. Introduction

Thailand has been the world's largest natural rubber producer since 2003, and has a share of about 35% of the latex produced worldwide (RRI, 2008). In 2011, Thailand produced about 3.4 million tons of fresh latex with an average yield of 1.6 ton fresh latex per hectare (OAE, 2012). The fresh latex is tapped and collected as a liquid, and then processed to primary rubber products. The primary rubber products are then processed into various final rubber products. Important primary rubber products include concentrated latex, block rubber, and ribbed smoked sheet rubber. Concentrated latex is the primary rubber product used as the raw material for dipped rubber products such as condoms, gloves, balloons, and infant pacifiers. Most of concentrated latex (about 70%) produced in Thailand is exported, mainly to European countries, China, India and Malaysia (RRI, 2012). In 2011, Thailand exported about 880,000 tons of concentrated latex, with a value of 77,000 million baht (OAE, 2012).

Since natural rubber and concentrated latex are being exported to the international market, the requirement of information on sustainable production has been becoming inevitable. Therefore, it has been challenging for Thai rubber entrepreneurs to seek appropriate measures towards producing environmentally friendly rubber products. The production of concentrated latex is an energy-intensive process, and contributes to several environmental problems such as water pollution (acidic wastewater), malodorous

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0959-6526/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jclepro.2013.11.016

problems (odor of rubber, and chemicals), and toxicity from the use of chemicals (such as sulfuric acid and ammonia). Tekasakul and Tekasakul (2006) described the environmental problems that are caused by concentrated latex production. Wastewater from the concentrated latex processing mill is highly acidic due to sulfuric acid addition, whereas applications of ammonia and de-ammonization process result in malodorous problem and toxicity problems. Diesel combustion in the drying process contributes to air pollution. Several studies on "end-of-pipe treatment", especially on anaerobic wastewater treatment, have been published (e.g. Jawjit and Liengchareonsit, 2010; Leong et al., 2003; Nguyen, 1999; Rakkoed et al., 1999). Applications of "pollution prevention" approaches for concentrated latex production were presented by the Department of Industrial Work (DIW, 2001) and the Pollution Control Department (2005). The Safety Technology Office (STO, 2005) proposed several measures for energy conservation in rubber processing mills. In a recent study on greenhouse gases emissions of rubber industry in Thailand, we also included production of concentrated latex, and found that energy-related emissions are the main causes of greenhouse gases (Jawjit et al., 2010). Nevertheless, comprehensive evaluations of environmental performance of concentrated latex production have not yet been widely published.

The objectives of this study are 1) to analyze consumption of resources and energy, waste generation, emissions of pollutants, and the potential environmental impact through partial life cycle assessment, and 2) to investigate the options to reduce the environmental impact of concentrated latex production. In the next section an overview of the concentrated latex production process is presented, and the methodology is explained in Section 3. Section 4 presents results and a discussion on activity data, emissions inventories, and the potential impact assessment, and Section 5 focuses on the effects of the reduction options.

2. Concentrated latex production

The lifetime of rubber plantation in Thailand is about 20–25 years. After about seven years of plantation, rubber tree can be tapped for the fresh latex for 13–18 years (Allen, 2004). The usual method applied in Thailand to prevent premature coagulation is to add anti-coagulant to the latex in the tapping cups and collecting buckets in order to increase pH of latex. The anticoagulant must be added as soon as possible after the tree is tapped. Anti-coagulants used in Thailand are ammonia, sodium sulphite, formalin and Tetra methyl thiurum disulphide (TMTD) or Zinc oxide (ZnO). Ammonia is recommended and used commonly in Thailand because it is cheap and can be locally produced. The amount of ammonia to be added to latex for prevention of natural coagulation depends on the season and the distance from collection site to processing factory; longer transportation distances demand for a higher amount of ammonia. It is obvious that a higher added amount of ammonia will need a higher amount of acid for neutralization of the latex in the factory. Thai rubber farmers transport the preserved fresh latex to the concentrated latex processing mills by pick-up truck or 6-wheel truck.

A schematic diagram of concentrated latex production is presented in Fig. 1. When the preserved fresh latex arrives at the mill, a sample is drawn from the tank for a quick test for DRC (dry rubber content), and for the ammonia concentration. The latex is then transferred through a sieve into the reception tank. Ammonia, TMTD/ZnO, and DAP (Diammonium phosphate) are added, and the latex is then transferred into a dilution tank. The purpose of dilution is to bring the latex to a standard DRC, for optimum separating efficiency in the centrifuge and to meet the requirements for the concentrate that is to be produced. After thorough mixing, the rubber content and water is separated to produce the concentrated latex. There are four methods for producing the concentrated latex (centrifugation,

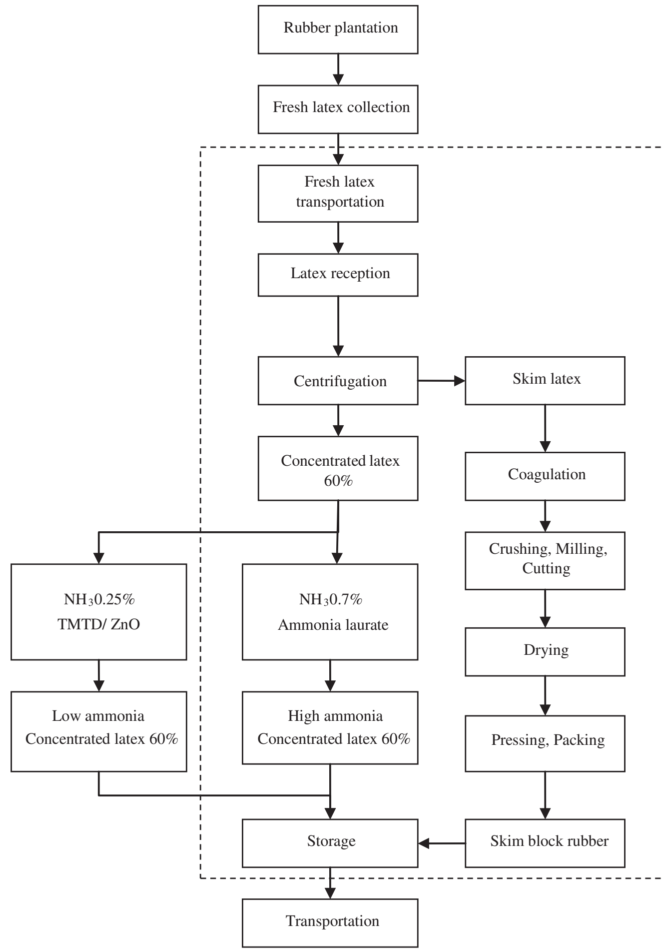

Fig. 1. Schematic diagram of concentrated latex production. The dotted lines indicate the system boundary of this study. See text (Section 2) for explanation.

creaming, evaporation, and electrodecantation). In Thailand centrifugation is the preferred method (DIW, 2005). After centrifugation, a concentrate fraction and a skim fraction are produced. The DRC in the concentrated latex is about 60–70%, but the water layer (skim latex) still contains up to 8% (by wet weight) dry rubber (Cecil and Mitchell, 2003). This water phase is discharged into a skimming tank for skim rubber production. If high-ammonia concentrated latex is to be produced, it is further ammoniated by adding the appropriate amount of ammonia gas (about 0.7%). For low-ammonia concentrated latex, about 0.25% ammonia and other preservatives (such as TMTD/ZnO) are added. Thereafter the concentrated rubber is put in the stainless steel containers for export (Nguyen, 1999). The skim latex can be further processed for skim block rubber. Rubber content in the skim latex can be coagulated by adding sulfuric acid. Nevertheless, before adding sulfuric acid, the skim latex is de-ammonized in order to reduce the amount of sulfuric acid used for coagulation. After a coagulation time of about 24–48 h, the coagulum is transformed by crushing, milling, and cutting machines to get rubber block. Then the rubber block is sent to a dryer, and is mechanically pressed to form skim block rubber (SBR).

3. Methodology

3.1. Goal definition

The objective of this study is to analyze the potential environmental impact associated with production of concentrated latex by