ENVIRONMENTAL IMPACTS OF CELLULOSE NANOWHISKERS OBTAINED FROM TROPICAL VEGETAL FIBERS

Maria Cléa Brito de Figueirêdo, Marília Ieda da Silveira Folegatti Matsuura , Men de Sá Moreira de Souza Filho, Morsyleide de Freitas Rosa, Ana Claudia Carneiro da Silva Braid, Amanda Ferreira Dias

Embrapa Tropical Agroindustry, Fortaleza, Brazil, Embrapa Environment, Jaguariúna, Brazil
clea.figueiredo@embrapa.br

Projeto Componente: PC6 **Plano de Ação:** PA5

Resumo

This work compares the environmental impacts of cellulose nanowhiskers obtained from four tropical vegetal fibers: cotton linter, cotton plume, green coconut husk, and sugarcane bagasse. Life cycle impact assessment was performed, according to ISO 14040, considering the following impact categories: eutrophication, human toxicity, ecotoxicity, and climate change. The evaluation showed that the lowest impacts occur when cotton plume is used as the source of cellulose to the extraction of nanowhiskers.

Palavras-chave: Life cycle assessment, cotton, linter, coconut fiber, sugarcane bagasse

Publicações relacionadas

Será publicado nos anais do 1ST INTERNATIONAL CONFERENCE ON NATURAL FIBERS, Guimarães, Portugal, 9-11 de Junho de 2013

Introduction

Vegetal fibers are an important source of cellulose for the extraction of nanowhiskers. During the last years, numerous processes have been developed to extract nanowhiskers from different fibers (ROSA et al., 2010; TEIXEIRA et al., 2010a; TEIXEIRA et al., 2010b; MORAIS et al., 2013). Cellulose nanowhiskers have great potential to reinforce the mechanical properties of different polymers and their production is expected to grow in near future. Despite outstanding developments in this area, environmental issues related to nanomaterials remain little understood. Figueiredo et al. (2012) studied the impacts of nanowhiskers obtained from cotton plume and green coconut fiber. This study expands that assessment, comparing the environmental impacts of nanowhiskers obtained from linter, cotton plume, coconut and sugarcane bagasse.

Materials and Methods

Life Cycle Impact Assessment, according to ISO 14040 (2006), was chosen to evaluate the environmental impact of 1 g of cellulose nanowhisker. The following processes were considered in this LCA study: agriculture production of fibers (cotton and sugarcane), production of chemical reagents, production and distribution of electricity, and extraction of nanowhiskers. Primary data was collected regarding cotton production in Brazil and extraction of nanowhiskers, while data from the other processes were obtained from the Swiss Ecoinvent database (FRISCHKNECHT et al., 2007).

Results and Discussion

The amount of resources, polluting loads, and consequent environmental impacts related to the production of one gram of cellulose nanowhiskers range according to the fiber used as source of cellulose (Tab 1). This occurs because of the different chemical composition (cellulose, lignin, and hemicelluloses contents) of vegetal fibers. Each fiber has an average chemical composition that determines the need to separate cellulose from other constituents. Fibers that are rich in lignin and hemicelluloses, such as green coconut and sugarcane bagasse, require more chemical reagents to extract cellulose and nanowhiskers, releasing effluents rich in organic matter. Thus, cellulose nanowhiskers obtained from cotton plume and linter use less energy, emit less polluting loads, and generate less environmental impacts along their life cycle than nanowhiskers obtained from coconut and sugarcane. The production and distribution of electricity used to extract nanowhiskers is the main process responsible for the impacts on eutrophication, toxicity and global warming.

Tab. 1 Life cycle impact assessment related to production of 1g of cellulose nanowhiskers

Impact Category	Unit	Linter*	Cotton*	Coconut*	Sugarcane*
Climate change	kg CO2 eq	0.28	0.13	1.09	1.89
Human toxicity	kg 1,4-DB eq	0.08	0.04	0.33	0.59
Freshwater eutrophication	kg P eq	0.0001	0.00003	0.0002	0.0004
Marine eutrophication	kg N eq	0.00002	0.00001	0.0001	0.0001
Terrestrial ecotoxicity	kg 1,4-DB eq	0.0003	0.0002	0.0002	0.0004
Freshwater ecotoxicity	kg 1,4-DB eq	0.001	0.001	0.004	0.007
Marine ecotoxicity	kg 1,4-DB eq	0.001	0.0005	0.004	0.008

* Extraction processes define by Morais et al (2013) to nanowhiskers obtained from linter; by Teixeira et al (2010a), from cotton; by Rosa et al (2010) from green coconut; and by Teixeira et al (2010b), from sugarcane.

Conclusions

This study shows that nanowhiskers obtained from fibers that have high cellulose content cause less life cycle environmental impacts, even when these fibers are not considered residues or co-products, such as cotton plume. In order to improve the environmental performance of extraction processes that use fibers with low cellulose content is necessary to also extract other co-products that are also of interest to industry, such as lignin. In this way, the environmental burden will be allocated to more than one product and may reduce the overall impact of cellulose nanowhiskers.

Acknowledgements

Os autores agradecem ao CNPq, Finep, Capes e Projeto MP1 Rede Agronano – Embrapa

Referencies

FIGUEIRÊDO, M. C. B. ROSA, M. F.; UGAYA, C. M. L.; SOUZA FILHO, M. M.; BRAID, A. A. A. S.; MELO L. F. L.. Life cycle assessment of cellulose nanowhiskers. Journal of Cleaner Production, v. 35, p. 130-139, 2012

FRISCHKNECHT, R.; JUNGBLUTH, N. Ecoinvent e Overview and Methodology. Swiss Center for Life Cycle Inventories, Dubendorf, 2007.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO). ISO 14040:2006. Genebra: ISO, 2007

MORAIS, J. P. S.; ROSA, M. S.; SOUZA FILHO, M.M.; NASCIMENTO, L.D.; NASCIMENTO, D.M.; CASSALES, A. R. Extraction and characterization of nanocellulose structures from raw cotton linter. Carbohydrate Polymers, v. 91, p.229-235, 2013

ROSA, M. F.; MEDEIROS, E. S.; MALMONGE, J. A.; GREGORSKI, K. S.; WOOD, D.F.; MATTOSO, L. H. C.; GLENN, G.; ORTS, W.J.; IMAM, S.H. Cellulose nanowhiskers from coconut husk fibers. Carbohydrate Polymers, v. 88, p. 83-92, 2010

TEIXEIRA, E. M.; CORRÊA, A. C. C.; MANZOLI, A.; LEITE, F. L.; OLIVEIRA, C. R.; MATTOSO, L. H. C. Cellulose nanofibers from white and naturally colored cotton fibers. Cellulose, v. 17, p.595-606, 2010a

TEIXEIRA, E. M.; BONDANCIA, T.J.; TEODORO, K. B. R.; CORRÊA, A. C.; MARCONCINI, J. M.; MATTOSO, L. H. C. Sugarcane bagassewhiskers: extraction and characterizations. Industrial Crops and Products, v. 33, p.63-66, 2010b