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Life cycle assessment during research and development of nanoproducts

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Abstract – The need to ensure that the production of nanoproducts is environmentally sound implies in a choice of an environmental impact assessment approach to evaluate these products. This work aims to present the life cycle assessment (LCA) approach, discussing its benefits and challenges when used during research and development (R&D) of nanoproducts.

In order to guarantee the compliance of innovations based on nanotechnology with environmental sustainability principles and goals, environmental institutions such as the European Commission for Science and Research and the American Environmental Protection Agency have fostered environmental impact evaluations of nanomaterials and nanoproducts made of these materials. Among the methodological approaches available to perform this evaluation, life cycle assessment (LCA) has been pointed out as the one that presents more comprehensive results to evaluate environmental impacts of products [1].

LCA can be used to evaluate the possible environmental impacts of nanoproducts upon ecosystems and human health, considering different stages of their life cycle: raw material production; nanomaterial production; nanomaterial use in the production of nanoproducts; and, final disposal of nanomaterials and nanoproducts. Although current LCA studies may not necessarily encompass all these stages in the first moment, this approach calls attention to the need to consider the other life cycle stages in future studies.

LCA studies start with the definition of its purpose and of the product system boundary (life cycle stages and processes that will be evaluated) [2]. Afterwards, data is collected during the inventory phase and then related to environmental impacts. At last, an interpretation phase is necessary.

LCA is usually used for existing products in which the processes are already defined and data can be collected. Nevertheless, in the earlier stages of a product development, the better environmental performance can be achieved. Comparison between new and current processes or products are of major importance in the development of innovations, in order to assure lower environmental and higher socioeconomic impacts of proposed technological routes. The idea is that LCA developed during R&D of nanoproducts can provide information about: i) the identification of relevant environmental aspects (resources and emissions) of a specific process; ii) the comparison among possible production or final disposal processes; and iii) the comparison among products (nanomaterials or nanoproducts).

Therefore, the aim of this study is to consider aspects of LCA that may be adapted in order to apply this approach during the Research and Development (R&D) phase of nanoproducts. In order to achieve this aim, a review about the current R&D processes and LCA was performed. As a result, some considerations are made.

One important aspect is the uncertainty in inventory data of production processes of nanoproducts. Although resources and emissions can be measured considering a process developed and occurring at the laboratory scale, changes is mass and energy flows will happen when the process scale up is performed. Therefore, the sensitive analysis in this case come to be even more important, being important the definition of scenarios of efficiency for different material flows.

Another aspect is the need to perform toxicological risk assessment studies of nanoproducts along with LCA. LCA methods that account for toxicological and ecotoxicological impacts do not consider yet the toxicity potential of nanoproducts. The emission of traditional chemical substances, whose toxicological tests were performed and data were made available related to transport and dose-response (e.g.: acetic acid), have already been taken into account by current LCA toxicity methods. Since no such information is currently available for most of the nanomaterials and nanoproducts, there is a clear need for further research to account for the toxicity potential of nanoproducts in LCA.

The next step of this work will be to define a methodological strategy to use LCA in the R&D of nanoproducts and apply it in the evaluation of nanofibers obtained from different raw materials such as coconut husks, sugar cane bagasse and cotton. This work has been supported by Embrapa´s Nanotechnology Network (Agronano).

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