Life cycle assessment of the supercritical antisolvent process: PVP/prednisolone coprecipitated microparticles

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The oral drug administration is the most employed route of drug delivery, because of high patient compliance, ease of ingestion, pain avoidance, and versatility to accommodate different types of drugs. However, one of the major problems with the design of oral dosage forms is linked with their poor bioavailability, which depends on several factors. Among them, the most frequent causes of low oral bioavailability are attributed to poor solubility in water and low permeability. Therefore, large doses are required to reach the therapeutic level, with resulting undesired effects.
Prednisolone (PD) is one of the most prescribed glucocorticoids; immediate-release PD tablets are generally used for different severe inflammatory disorders, such as tendinitis or heart inflammation of rheumatic origin, in the treatment of rheumatoid arthritis in association with other drugs, in the treatment of allergies (such as bronchial asthma or atopic dermatitis). PD bioavailability can be enhanced entrapping it in a water-soluble biocompatible polymer obtaining coprecipitated particles. Supercritical fluids-based processes have been extensively proposed in the literature for the coprecipitation of pharmaceutical compounds, in order to overcome the limitations of the conventional techniques.
In this work, the supercritical antisolvent (SAS) process was used to coprecipitate PD with polyvinylpirrolidone (PVP). In correspondence of the optimized operating conditions, corresponding to 90 bar, 40°C, 20 mg/mL ethanol and a polymer/drug ratio equal to 5/1, spherical microparticles with a mean diameter of 2.4 μm and an improved dissolution rate (5 times faster with respect to unprocessed PD) were obtained.
Since supercritical fluids-based technologies are considered as “ecofriendly”, it is important to study the environmental emissions due to a specific production. Therefore, in correspondence of the optimized operating conditions, the environmental impacts of the production of the coprecipitated powders were evaluated, following a Life Cycle Assessment (LCA) approach. All the emissions to air, water and soil were reported to a 180 mg tablet containing 150 mg of the polymer and 30 mg of the active principle. Data were analysed using SimaPro 8.5.2 software, whereas the Ecoinvent 3.1 database and primary data were used for the life cycle inventory, according to the reference standard for LCA (i.e., ISO 14040-14044).
A “from gate to gate” approach was followed; therefore, the system boundaries were set from the preparation of the liquid solution constituted by PVP and PD dissolved into ethanol to the attainment of the coprecipitated powder. ReCiPe method was used to evaluate the effect of the production on the midpoint and damage impact categories.