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## Reducing carbon footprints of metered dose inhalers

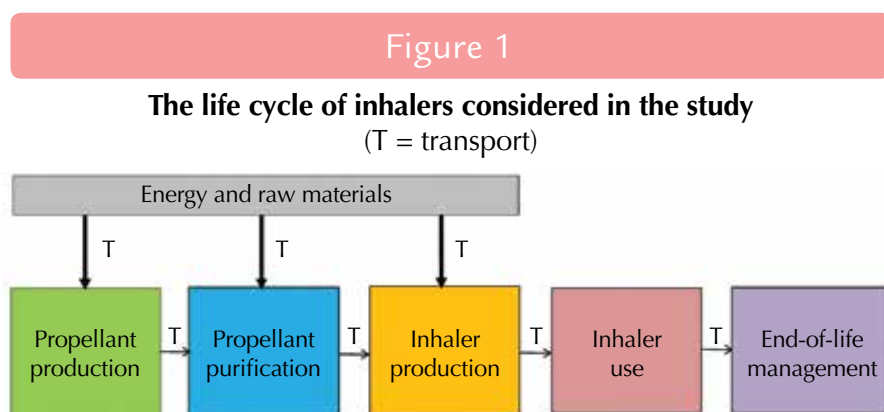
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It is estimated that more than 630 million pressurized metered dose inhalers (pMDIs) are manufactured annually worldwide, using over 10,000 tons of propellants.<sup>1</sup> The chemicals used as propellants within these pMDIs have been under scrutiny due to environmental concerns. The adoption of the Montreal Protocol, in 1989, initiated a transition within the inhalation segment of the pharmaceutical industry from ozone-depleting chlorofluorocarbons (CFC-11 and CFC-12), which were originally used as propellants, to hydrofluorocarbons; mainly HFC-134a and, to a lesser extent, HFC-227ea. Besides reducing the impact on the ozone layer, the move to HFC-134a from CFC-12 resulted in an order-of-magnitude reduction in the global warming potential (GWP) associated with propellant use ( $\text{GWP}_{\text{CFC-12}} = 10,200 \text{ kg CO}_2 \text{ eq/kg}$  versus  $\text{GWP}_{\text{HFC-134a}} = 1,300 \text{ kg CO}_2 \text{ eq/kg}$ ).<sup>2</sup> Despite this, some believe that the GWPs of HFC134a and HFC-227ea are still high and the industry is exploring various options for further reducing the carbon footprints associated with pMDIs.

Some of these options include the use of alternative devices, such as dry powder inhalers (DPIs) and nebulizers, or use of a different propellant in pMDIs. In this regard, it has been suggested that



1,1,-difluoroethane (HFC-152a) has potential as a propellant and its safety and formulation behavior are being investigated.<sup>3</sup> Recently, the University of Manchester<sup>4</sup> carried out a comparative study to assess the carbon footprints of the following options:

pMDI with HFC-134a propellant;  
pMDI with HFC-152a propellant;  
and

blister-based dry powder inhaler (DPI).

### Study methods

The study was carried out using life cycle assessment (LCA), following the ISO14040/14044 methodology.<sup>5, 6</sup> LCA is an environmental management tool that can help in understanding environmental impacts of products across their life cycles, from acquisition of raw materials through manufacture and use to final disposal.

As indicated in Figure 1, the scope of the study was from “cradle to

grave,” including the extraction of raw materials, manufacture of the propellants and inhalers, the use and the end-of-life disposal of the inhalers. The impacts of drug manufacturing were not considered. The unit of analysis was defined as the “delivery of 100 doses of inhaled medicine,” to represent a typical pMDI device in use. This was considered to be equivalent to 1.67 packs of a 60-dose DPI. Assuming that the pMDIs require an approximately constant number of moles of propellant, the 100-dose HFC-134a and HF-152a inhalers were assumed to contain 18 g and 11.7 g of propellant, respectively. A pMDI dose was assumed to consist of two “puffs.”

The inventory data for material inputs and outputs as well as energy consumption for the production of the propellants were supplied by Mexichem Fluor (Cheshire, UK) and supported by the background data from the Ecoinvent v3.3 database.<sup>7</sup> The study was con-

ducted using GaBi 7.3 software. A number of environmental impacts were estimated but, owing to space limitations of this article, the focus here is on the carbon footprint, summarizing the key findings. The Intergovernmental Panel on Climate Change (IPCC) methodology was utilized to calculate the carbon footprints.<sup>2</sup>

## Results

The LCA results show that the cradle-to-grave carbon footprint of 100 doses (200 puffs) of an HFC-152a inhaler is 1.8 kg CO<sub>2</sub> eq. (Figure 2). This is an order of magnitude lower than the carbon footprint of the HFC-134a inhaler but is higher than the particular DPI device investigated here. The main contributor to the impact of both types of pMDIs is the emission of propellants to the atmosphere during the use of the device, contributing 99% to the carbon footprint of the HFC-134a inhaler and 89% to the HFC-152a inhaler. In the case of the DPI, the raw materials are the dominant contributors (71%), followed by the production process (21%). The contributions of transport and waste disposal is insignificant for all three inhalers. Other parameters, such as the Teflon coating of the pMDI device, were also considered but did not affect the results.

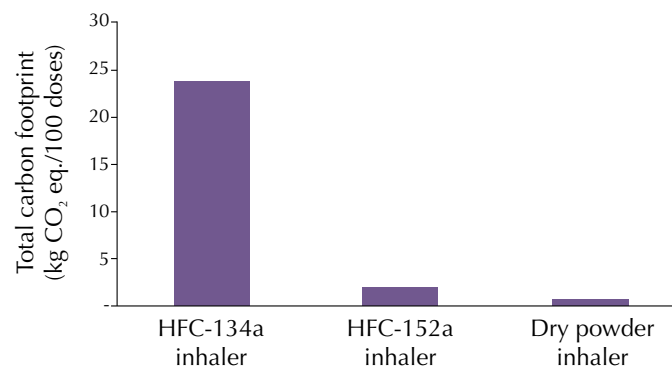
## Conclusions and future outlook

Climate change is of great global concern and there is a growing demand for reducing carbon footprints of all products used by consumers. In response, industries are focusing on developing innovative products and efficient processes to address this global challenge.

The results of this study show clearly that the development of HFC-152a inhalers can significantly reduce the carbon footprint

Figure 2

### Comparison of the carbon footprints of inhalers



Total carbon footprint	23.65	1.80	0.65
Waste disposal	0.01	0.01	0.04
Use (propellant emissions)	23.40	1.61	—
Transport	0.01	0.01	0.02
Production	0.06	0.03	0.13
Raw materials	0.17	0.13	0.46

of pMDIs. However, the successful deployment of HFC-152a propellants in pMDIs will depend on safety and formulation behaviors, which are still being investigated. Obviously, pharmaceutical companies must ensure safe and effective delivery of drugs while designing and developing healthcare products and devices. Achieving this while reducing environmental impacts is a win-win situation.

Although in this study a dry powder inhaler (DPI) had the lowest carbon footprint, it is not yet technically or economically feasible to completely replace HFC pMDIs, due to cost, technical and patient-acceptability factors. Therefore, pharmaceutical companies should continue to look to other techniques for minimizing propellant emissions, including reducing the size of metering valves, propellant usage per dose and propellant recovery for spent or partly consumed pMDIs. Such steps will continue to be of value should HFC-152a be introduced on a commercial basis.

## Acknowledgements

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