



Underlying reaction mechanisms support narrowing exemptions of ODS and HFC feedstocks under the Montreal Protocol

Yiyao Wei¹ and Song Gao^{1,2}

¹Duke Kunshan University, Kunshan, China (song.gao212@duke.edu)

²Duke University, Durham, The United States of America (song.gao212@duke.edu)

As the most effective multinational environmental agreement (MEA), the Montreal Protocol on Substances that Deplete the Ozone Layer has eliminated the production of about 98% of the ozone-depleting substances (ODSs). Moreover, the most recent Kigali Amendment to the Montreal Protocol will phase down the production of hydrofluorocarbons (HFCs) with high global warming potentials. The use of ODSs and HFCs as feedstocks is currently exempted from the control of the Montreal Protocol and its associated amendments because it was falsely assumed that there were no feedstock emissions and that products made from feedstocks were safe in manufacture, use and disposal.

In this paper, we demonstrate a previously missing mechanistic link between ODS and HFC feedstocks and a variety of chemical products that resist environmental degradation, including fluoroplastics and elastomers. We illustrate chemical reaction pathways where specific ODS and HFC gaseous molecules are made into a multitude of macromolecules that pollute the atmospheric, terrestrial and aquatic environments and harm industry workers during the manufacture. For example, the feedstock HCFC-22, itself made from chloroform (an associated feedstock), can be made into polytetrafluoroethylene (PTFE), a fluoroplastic in widespread use. Fluoropolymers' extreme persistence in the environment and harmful emissions associated with their manufacture and disposal justify curtailing the upstream production of plastics from ODS and HFC feedstocks. We show that a variety of feedstock molecules and their byproducts go into the atmosphere and may alter atmospheric chemical composition.

These reaction mechanisms suggest that ODS and HFC feedstocks be narrowed in their exemptions under the Montreal Protocol, via further amendments and adjustments. Considering also the global warming potential and ozone depletion potential of these feedstocks, this policy response can help mitigate stratospheric ozone depletion, climate change and plastics pollution.