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Evaluation of the impact of future HFC replacements on air pollution and global warming

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Abstract

The phase-out of the consumption and production of (stratospheric) ozone-depleting chlorofluorocarbons (CFCs) was completed in 2010, while the scheduled phase-out of most hydro chlorofluorocarbons (HCFCs) is expected by 2030. During the gradual disappearance of HCFCsover the coming decades, hydro fluorocarbons (HFCs) were proposed as long-term replacements in several industrial applications. Despite HFCs are non-depleting ozone substances, most of them are potent greenhouse gases (GHGs) that affect the radioactive forcing of climate change. Their strong IR absorption in the atmospheric window and their long atmospheric lifetime result in high global warming potentials (GWPs). To decrease climate forcing, the emissions of high-GWP HFCs have to be reduced and replaced by substances that have low impact on climate. Among these, hydrofluoroolefins (HFOs) and per fluorinated compounds (PFCs) are expected to be good alternatives to HFCs. For instance, CF3(CF2)2CH=CH2 (HFO 1447fz) is currently being considered as a substitute of HCFC-141b as expansion agent in polyurethane foams. Or CF3CH=CH2 (HFO-1243zf) could replace CF3CH2F (HFC-134a) in air-conditioning units. To assess the environmental impact of the potential widespread use of these potential substitutes, an evaluation of the atmospheric chemistry is needed. Degradation of pollutants in the troposphere is usually initiated by OH radicals(the main diurnal oxidant) and, under certain circumstances, by Cal atoms. In our group, the rate coefficients for the OH and Cal reactions with some HFOs and PFCs have been determined under tropospheric conditions of temperature and pressure. Identification of secondary gaseous products and organic aerosols was also carried out simulating a clean and polluted atmosphere. The IR spectra of these species were recorded in order to calculate their radioactive efficiency. All these results allow the estimation of the atmospheric lifetime, GWP and the photochemical ozone creation potential of the HFC substitute. Therefore, we can predict the impact of future emissions on air quality and global warming. Many hydro fluorocarbons (HFCs) that are widely used as substitutes for ozone-depleting substances (now regulated under the Montreal Protocol) are very potent greenhouse gases (GHGs). China's past and future HFC emissions are of great interest because China has emerged as a major producer and consumer of HFCs. Here, we present for the first time a comprehensive inventory estimate of China's HFC emissions during 2005-2013. Results show a rapid increase in HFC production, consumption, and emissions in China during the period and that the emissions of HFC with a relatively high global warming potential (GWP) grew faster than those with a relatively low GWP. The proportions of China's historical HFC CO2-equivalent emissions to China's CO2 emissions or global HFC CO2-equivalent emissions increased rapidly during 2005-2013. Using the "business-as-usual" (BAU) scenario, in which HFCs are used to replace a significant fraction of hydro chlorofluorocarbons (HCFCs) in China (to date, there are no regulations on HFC uses in China), emissions of HFCs are projected to be significant components of China's and global future GHG emissions. However, potentials do exist for minimizing China's HFC emissions (for example, if regulations on HFC uses are established in China). Our findings on China's historical and projected HFC emission trajectories could also apply to other developing countries, with important implications for mitigating global GHG emissions.

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