EPA model applied to investigate human and ecosystem impact of alternative motor vehicle refrigerant

Issue

The refrigerant chlorofluorocarbon-12 (known by many as CFC-12 or Freon™) has been widely used in motor vehicle air conditioning systems. Beginning in the 1990s, it was largely replaced by hydrofluorocarbon (HFC)-134a as the dominant refrigerant worldwide.

Both CFC-12 and HFC-134a have significant global warming potential. As a result, air quality professionals at EPA and industry reinvigorated their search for alternative refrigerants that do not (1) deplete ozone in the stratosphere, (2) promote unsafe levels of ground-level ozone production, or (3) contribute to global warming.

The European Union has begun using a new alternative refrigerant, HFC-1234yf, which appears to be the choice among global car manufactures for future vehicle air conditioning systems. It does not contribute to stratospheric ozone depletion and has a negligible direct impact on global warming.

However, the new alternative produces ground-level ozone and an aquatic toxin (trifluoroacetic acid). The vehicle air conditioning refrigerant currently in wide use, HFC-134a, also has these characteristics.

The issue scientists needed to determine was whether use of the alternative refrigerant would cause problems for human and ecosystem health that did not exist before.

Science Objective

EPA scientists and regulators, together with researchers in industry sought to determine whether the potential adverse effects from the European Union's alternative refrigerant — HFC-1234yf —presented a greater overall risk compared to other alternative refrigerants used in motor vehicles.

To accomplish this, EPA scientists used EPA's Community Multiscale Air Quality (CMAQ) model to simulate the atmospheric reactions from this alternative refrigerant to determine its impact on ozone and trifluoroacetic acid formation. This was the first time that a new alternative refrigerant was studied in a comprehensive regional air quality model.

The first step was to develop a spatial and temporal inventory of refrigerant emissions across the United States, since this emissions inventory did not exist. The inventory identified potential future HFC refrigerant emissions based on air conditioner efficiency, system leakages, servicing and vehicle end-of-life leakages(1).

Next, EPA scientists modified the CMAQ model to account for the photochemical reactions of HFC-1234yf and its degradation products, and to determine the impact on production of trifluoroacetic acid, including concentrations that may be re-deposited on Earth's surface and potentially impact open waters. They then layered on a real-world perspective by examining three summertime scenarios across the United States(2).

Results and Impact

The analysis by EPA concluded that:

- Concentrations of ozone from HFC-1234yf emissions from car air

conditioners were not significant enough to increase ground-level ozone concentrations,
- HFC-1234yf has a significantly lower global warming potential (4) than the widely used HFC-134a refrigerant (1430), and
- Trifluoroacetic acid concentrations in rainwater were only 1/800th to 1/80th the level at which adverse effects would be observed in sensitive aquatic plants.

This research enabled EPA to make better estimates of potentially harmful impacts of emissions from the more than 300 million U.S. vehicles expected to be in use by 2013.

Based on these and other findings, EPA Administrator Lisa P. Jackson signed a new rule on Feb. 24 listing HFC-1234yf as acceptable in new cars and light-duty vehicles under EPA's Significant New Alternatives Policy (SNAP) Program. The SNAP Program is the only government program worldwide that reviews health and environmental impacts of substitutes for ozone-depleting substances.
This research enabled EPA to provide an additional refrigerant choice to the automotive industry and help lower overall risk to human health and the environment.

References

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