Perfluorocarbon Tracers

A tracer is an indicator added to a system so that movement of mass can be easily detected.

Tracers are:
- Present in the atmosphere at background levels from less than 1 to ~9 parts per quadrillion
- Detectable at background levels using specialized gas chromatography with electron capture detection

The Tracer Technology Group field programs validate and improve models used to predict transport in the atmosphere on global, regional, and local scales and in rural and urban environments. These programs include:
- The New York City Urban Dispersion Program (NYC UDP),
- The Crystal City Urban Transport Study (CCUTS),
- The New York City Subway-Surface Air Flow Exchange Project (S-SAFE),
- Pentagon Atmospheric Nontoxic Dispersion Analysis Program (PANDA),
- and the United Kingdom Department for Transport London Underground Airflow Study.

Perfluorocarbon Compounds Used as Tracers

These compounds are:
- chemically inert,
- non-flammable,
- have no biological effects.

Analysis

- Gas chromatography with an electron capture detector (ECD).
- The GC/ECD methods have the sensitivity to quantify background levels of PFT if the material in 1.5 liters of ambient air collected.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Chemical Name</th>
<th>Formula Molecular weight (g mol⁻¹)</th>
<th>boiling Point (°C)</th>
<th>density (g cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDCB</td>
<td>Perfluorobutyldicyclopentane</td>
<td>C₃₅F₆₂</td>
<td>450</td>
<td>1.67</td>
</tr>
<tr>
<td>PMCP</td>
<td>Perfluorocaprylpropyne</td>
<td>C₈₃F₁₆₀</td>
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<tr>
<td>PMCH</td>
<td>Perfluoromethylcyclohexane</td>
<td>C₈₈F₁₈₂</td>
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<td>1.79</td>
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<tr>
<td>o-PDCH</td>
<td>Perfluorodimethylcyclohexane</td>
<td>C₁₅₂F₂₄₈</td>
<td>102</td>
<td>1.83</td>
</tr>
<tr>
<td>i-PCH</td>
<td>Perfluorophenyldicyclopentane</td>
<td>C₉₀F₁₄₆</td>
<td>130</td>
<td>1.9</td>
</tr>
<tr>
<td>PTCH</td>
<td>Perfluorotriphenylcyclohexane</td>
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Tracers will help in this effort in four ways:
1. They will be used to directly measure, independent of any atmospheric transport model, the sensitivity of both in situ (tower and aircraft) and remote column CO₂ measurements to urban emissions. By knowing the PFT release rate and the observed concentrations, we can directly map the influence functions (units of mole fraction per unit flux). This has not been done before to our knowledge.
2. They will be used to provide a unique and rigorous quantification of the accuracy and precision of the urban inversion system currently deployed in Indianapolis. We will solve for the known PFC emissions using our tower and aircraft measurements and our inversion system. We know of no other “known source” experiments; this would be the first-ever direct test of a regional atmospheric inversion system.
3. They will be used to identify and quantify uncertainties in the transport models (forward and inverse) used in regional atmospheric inversions.
4. They will be used to determine the representativeness of the existing INFLUX urban measurement network, and the added value of column CO₂ measurements.

A simple Gaussian plume model can be used to scale the PFT release rates necessary for providing strong signals. Sample results are shown below indicate that a release rate of about a gram of PFT per minute will result in a signal 10 times greater than background level at dilution factors of 10⁹ at distances up to 80 km downwind of the city.

The tracer release offers a unique capability to test an atmospheric inversion system. The tracer release data could be applied to any atmospheric inversion system to solve for the PFT emissions. By sampling the PFTs from the INFLUX tower observational network, the sampling design for INFLUX is integrated into this test.

If we are able to release multiple PFTs at known distances upwind of one or more INFLUX towers, we can directly observe the sensitivity of the tower to emissions from various points upwind, and thus test the ability of the Lagrangian particle dispersion model (WRF-LPDM) system to reproduce this influence function.