In-Vitro Evaluation of pMDI Spray Development of HFA134a, HFA152a and HFO1234ze(E)

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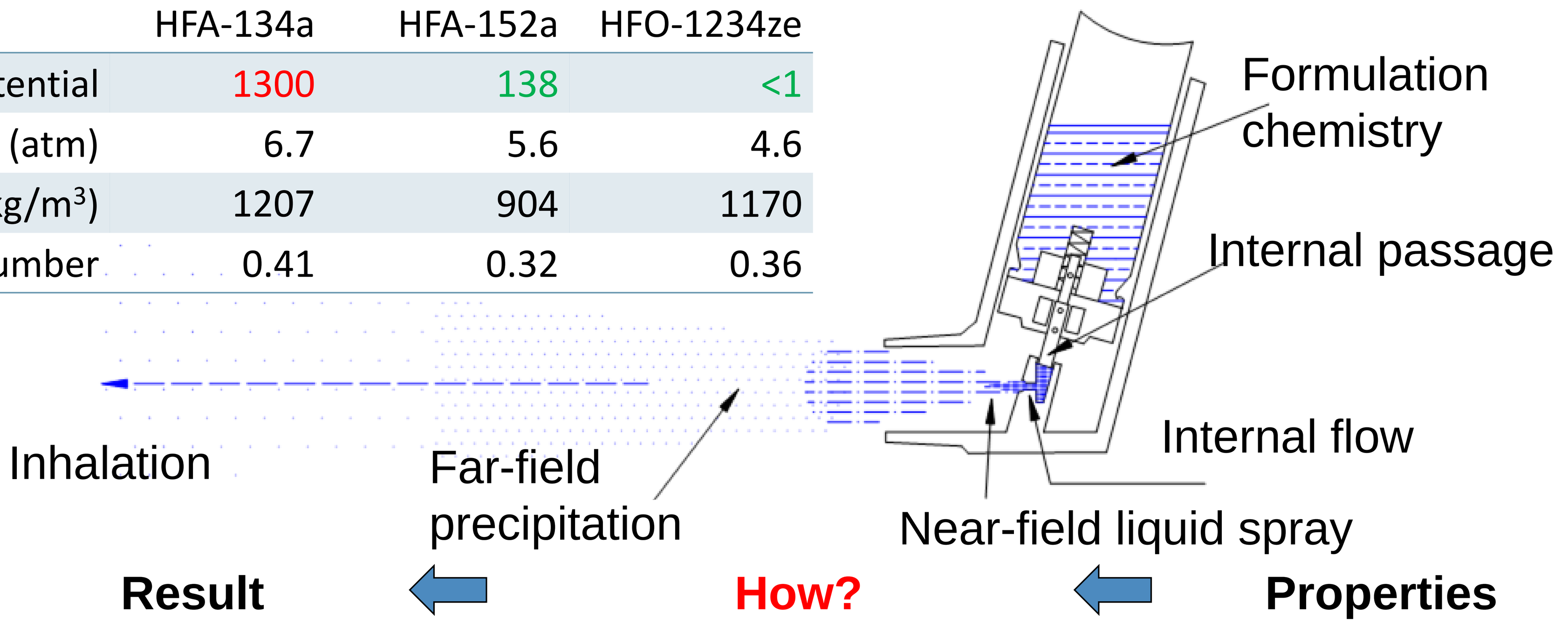
Motivation and Objective

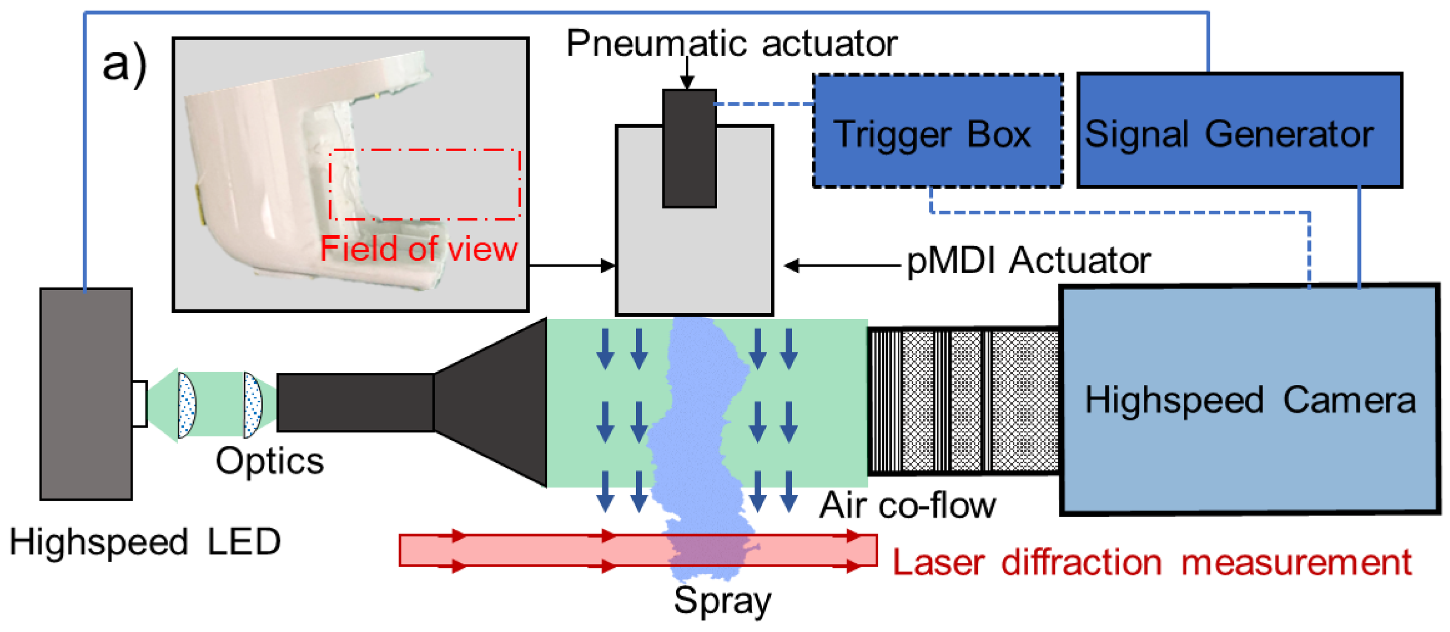
- The Fact: The transition toward low GWP pMDI propellants is underway. The two promising alternative propellants are the HFA-152a and HFO1234ze(E).
- The Issue: With measurable differences in the thermodynamic and physicochemical properties, little is known about the formulation spray driven by these alternative propellants, which directly changes the delivered dose
- The Goal: The current study aims to bridge the gap by performing direct comparisons of HFA-134a, HFA-152a and HFO-1234ze(E) sprays.

	HFA-134a	HFA-152a	HFO-1234ze
Global warming potential	1300	138	<1
Saturation pressure (atm)	6.7	5.6	4.6
Liquid density (kg/m³)	1207	904	1170
Jakob Number	0.41	0.32	0.36

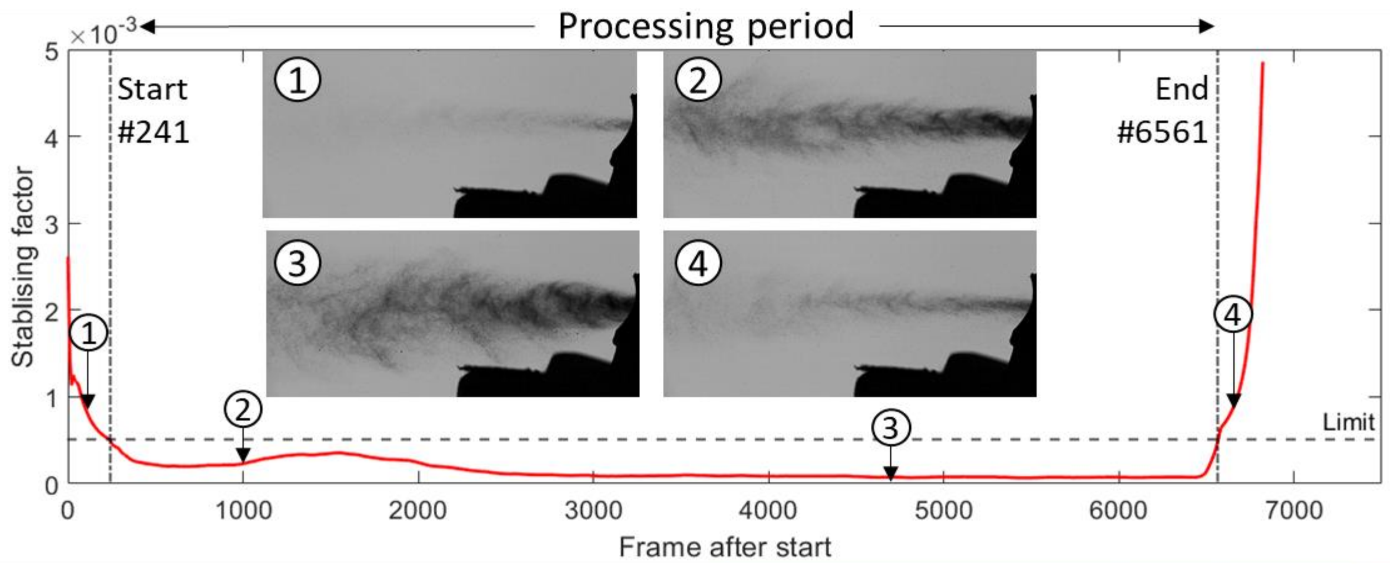


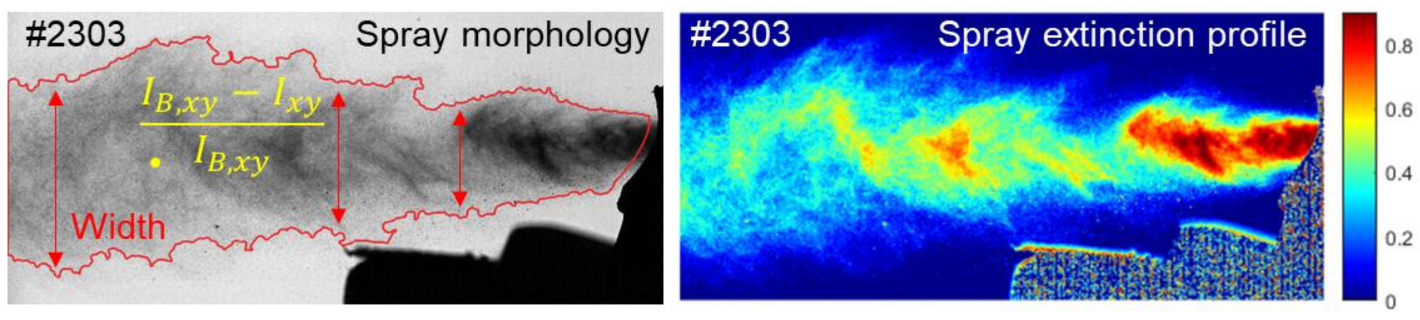
Methodology

- Two formulations per propellant to model a suspension and a solution pMDI formulation.



- High-speed imaging of transient spray development at 50 kHz and separate laser diffraction measurements for droplet sizing.
- Image post-processing was performed during the quasi-steady period of the spray development.
- For each image, spray widths were measured at 10 axial locations. A pixel-wise extinction measurement was also conducted.





Result and Discussion

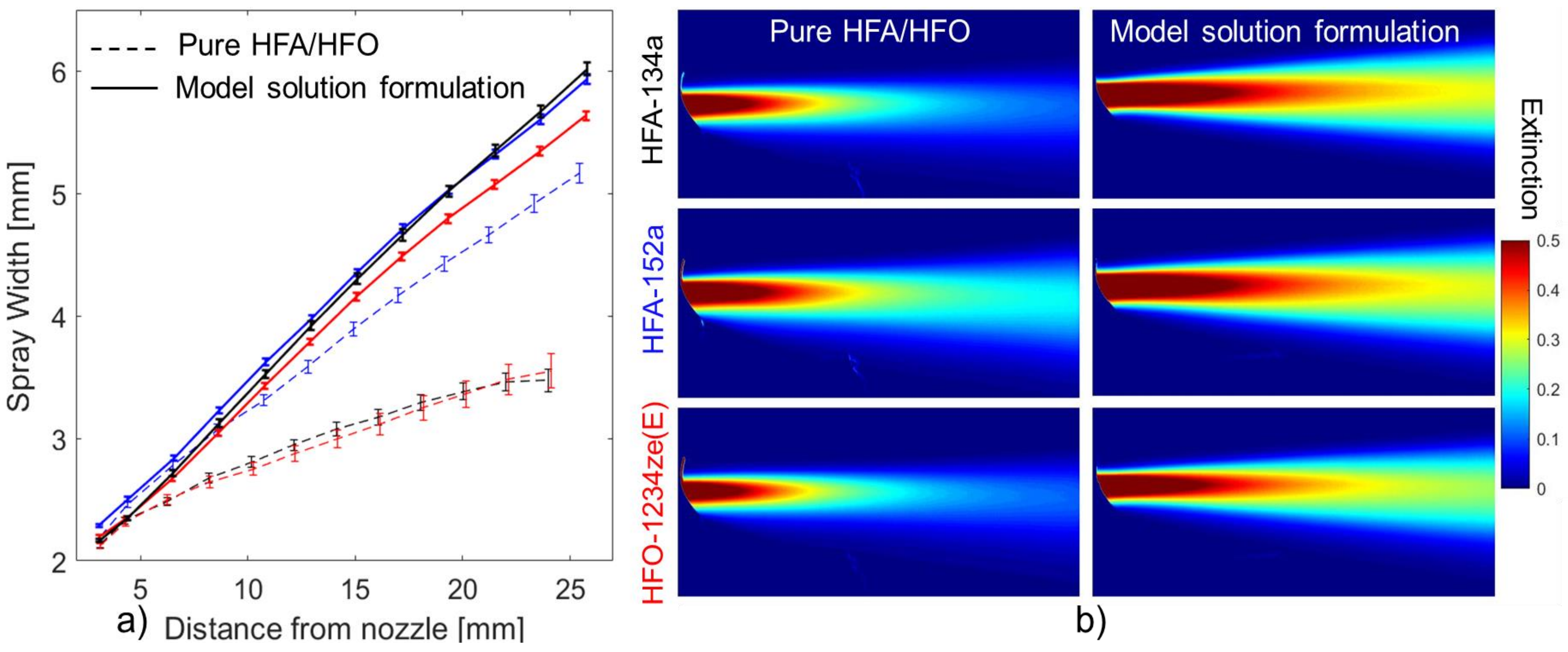


Figure 1. The calculated spray width as a function of horizontal distances from the orifice (a). Ensemble-averaged mean extinction profiles for each formulation (b).

- Placebo - Similar spray width and extinction profiles were measured for HFO-1234ze(E) and HFA-134a sprays. HFA-152a shows a larger spray width and larger extinction, i.e. a denser spray structure.
- Solution - Broader and denser spray structures were observed compared to placebos. Both HFA-152a and HFO1234-ze(E) showed comparable spray profiles as compared to that of HFA-134(a)

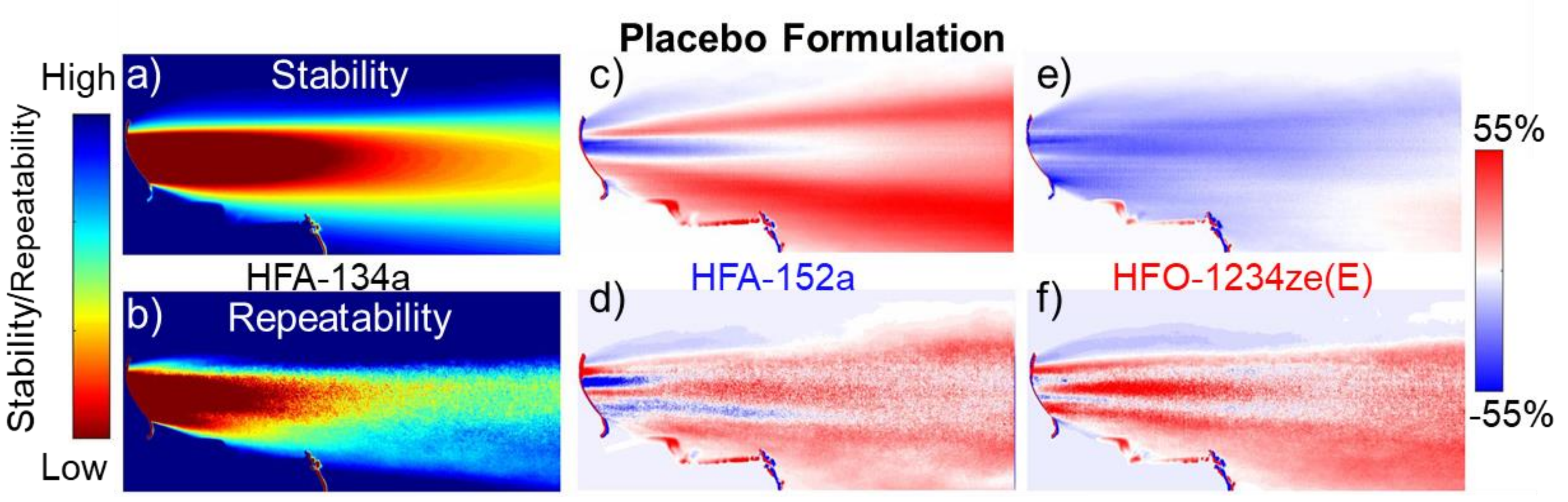


Figure 3. Spray stability and repeatability contour maps of HFA-134a placebo formulation (a and b). The difference heat maps as compared to that of HFA-134a for low GWP propellants (c-f).

- The stability of a spray indicates the fluctuation in its temporal development, which will influence sensitivity to inhalation timing and delivered dose.
- The repeatability is a measurement of the variation between different sprays, which will influence dose-to-dose repeatability.

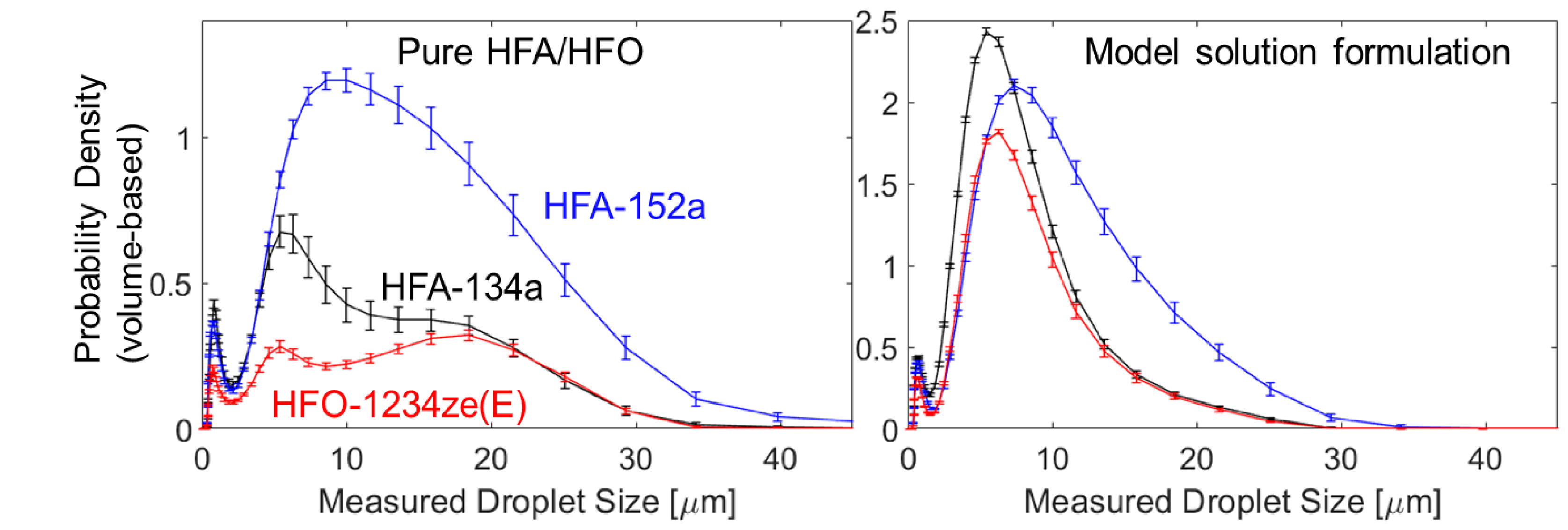


Figure 2. The measured droplet size distribution for the placebo (left) and solution (right) formulations.

- Placebo - HFA-152a and HFO-1234ze(E) are skewed toward larger sizes (>10 μm) compared to HFA-134a. In addition, the distribution of 152a is distinctly different.
- Solution - The moderated impact of propellant variation is demonstrated – alternative propellants show a larger resemblance to the case of HFA-134a as compared to that of the placebo sprays.

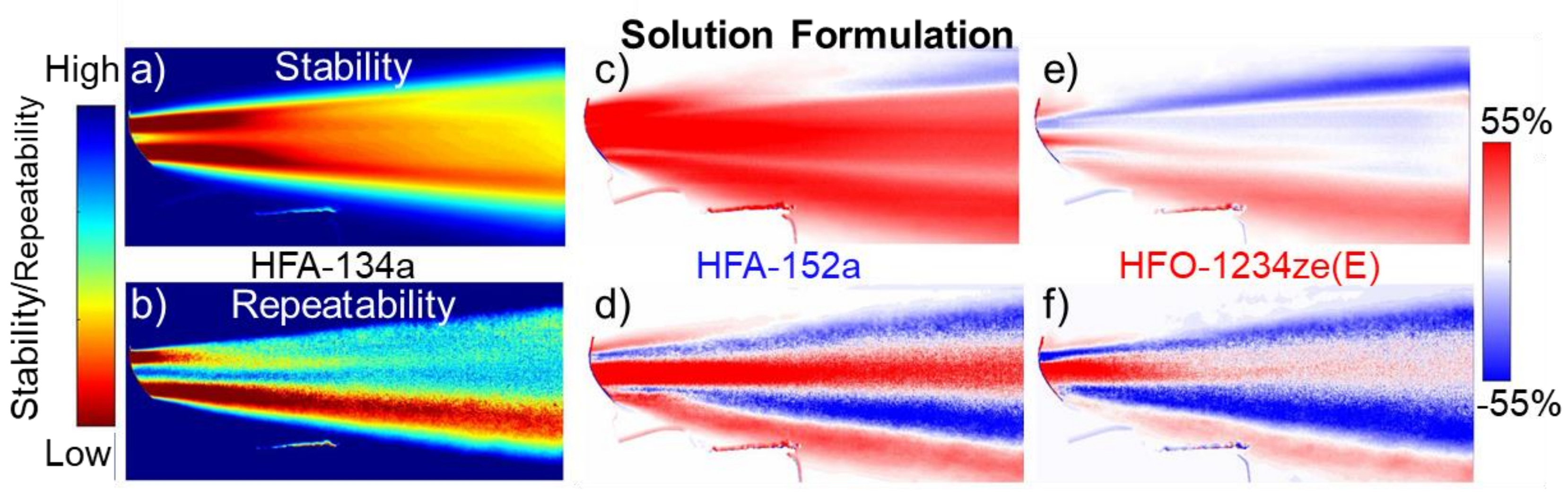


Figure 4. Spray stability and repeatability contour maps of HFA-134a solution formulation (a and b). The difference heat maps as compared to that of HFA-134a for low GWP propellants (c-f).

- Placebo - The HFA-152a placebo formulation is consistently less stable (Fig. 3c) and less repeatable (Fig. 3d). HFO-1234ze(E) shows improved spray stability (Fig. 3e) with reduced repeatability(Fig. 3f).
- Solution - HFA-152a shows an apparent reduction in stability (Fig. 4c) and an overall reduced repeatability (Fig. 4d). This is less problematic for HFO-1234ze(E), yet localised less-stable/repeatable regions within the spray are still presented.

Conclusion

- ✓ HFA-152a and HFO-1234ze(E) show promise as replacements for solution formulations, whereas uses in suspension formulations may prove more challenging.
- ✓ HFO-1234ze(E) showed a greater similarity to HFA-134a.
- ✓ Low GWP propellants show reduced spray stability and repeatability than sprays of HFA-134a.

Acknowledgement:

This work is supported by Kindeva Drug Delivery and the Australian Research Council (LP190100938, DP200102016).