Summary:

The oil sands (OS) in Alberta, Canada provide a significant source of SOA, necessitating lab studies to isolate contributions from different sources and chemical reactions. To address this knowledge gap, the authors use a custom oxidative flow reactor (OFR) to mimic different degrees of atmospheric oxidative aging for emissions from different OS-related precursors. In this work, the authors introduce the ECCC-OFR through single-species precursor experiments to assess the impacts of gas and particle wall losses and seeding, then use the ECCC-OFR to evaluate differences in OS-related SOA formation between several relevant sources. This is generally a clearly written manuscript, with compelling results that contribute important knowledge for both OS SOA chemistry as well as future OFR laboratory studies.

General Comments

[1] In the introduction (page 2, lines 22-24), the authors state that organic gases from the OS are mainly alkanes that react with the OH radical. However, one of the precursors that the authors use and discuss in the introduction is α-pinene. The choice of α-pinene is confusing in this context without further justification. From the manuscript, it seems that α-pinene was chosen because it was convenient to compare OFR operation to other studies. Does α-pinene have additional relevance for SOA in the OS region? Either way, it would be helpful for the author to address this choice early on in the manuscript. Additionally, under the ECCC-OFR operating conditions for these experiments (i.e., precursor concentrations, ozone concentrations), is there potential for the interfering α-pinene + ozone reaction to contribute significantly to SOA yields?

[2] Wall losses (Section 3.1.1): The authors state that vapor wall losses are likely minimal based on the diffusion timescale relative to the residence time within the reactor, then state the critical assumption that flow in the reactor is ideally laminar. Is this assumption solely based on fluid dynamics information from previously designed OFRs? The authors cite CFD done by Huang et al. (2017) for the CPOT on page 4 (lines 6-7) to justify the assumption, but I'm curious as to how the differences between the ECCC-OFR and the CPOT would change the fluid dynamics. For example, the ECCC-OFR has a straight outlet rather than a conical one like the CPOT. Is there potential for jetting or dead volume around the outlet? What are the benefits to sampling from the center line?

Technical Comments

[1] Page 2, Lines 19-20: The authors state that a single species approach to studying SOA formation is "impractical." To me, "impractical" implies some sort of logistical difficulty and sells the point short. I'd consider reframing this sentence to emphasize atmospheric relevance for the OS, which is critical to consider when performing lab studies.

[2] Page 2, Lines 21-22: Consider restructuring this sentence for clarity. Perhaps "Precursor emissions occur throughout the OS surface mining and processing production cycle, and they originate from sources including…"

[3] Page 2, Line 24: Define "OH" as "hydroxyl radicals (OH)" before using the abbreviation.

[4] Page 2, Line 28: "Complimentary" should be "complementary." This spelling should also be changed on page 3, line 13.

[5] Page 3, Line 6: Replace the semicolon after "vary" with a comma.

[6] Page 4, Line 11: Replace "Hg" with "mercury."

[7] Page 5, Line 5: Define the THC acronym here.

[8] Figure 1: Consider matching the color of the top and right axes to the alkane data points to visually distinguish the gas-phase data from the particle-phase data.

[9] Page 8, line 9: The sentence starting with “This despite” is not a full sentence.

[10] Page 10, line 21: Replace the semicolon after “mixtures” with a comma.

[11] Page 10, line 25: It would be helpful to cite the specific section in supporting information so the reader can easily flip to it as needed.

[12] Figure 4a and 4b: Consider emphasizing the different y axis scales between the two panels in either the text or the figure caption. Otherwise, the differences between seeded and non-seeded results can be difficult to pick out visually.

[13] I would be interested to see the AMS mass spectra for each OS-related oxidation experiment, perhaps in the supplement.