This study investigates the chemical evolution of SOA formed from reactions of phenolic compounds in the aqueous phase. The dataset that combines the AMS and DESI-MS measurements, in principal, provides important observations into the interplay of key processes including functionalization, fragmentation, and oligomerization in the SOA cloud processing. The role of aqueous photochemical aging in the phenolic SOA evolution is demonstrated in terms of transformation of elemental/molecular composition and volatility distribution. In view of this, I would recommend publication on ACP with some issues that require clarification.

General comments

1. The importance of aqueous phase photochemistry in the SOA aging relies on the availability of precursors. While results presented in the current study indicate that the aqueous photooxidation of phenolic compounds significantly alter the aqSOA signature, the abundance of phenolic compounds in the aqueous phase could substantially limit the power of this reaction scheme in the entire lifetime of phenol derived SOA. The authors are suggested to provide:

    1) The average level of phenolic compounds in ambient aerosols or clouds;
    2) Compare the lifetimes of phenols in terms of further oxidized by OH radicals in the gas phase, vs. transported and dissolved into liquid particles;
    3) Discuss the relative importance of different reaction pathways of phenolic compounds in the atmosphere, mostly, OH-initiated oxidation in the gas phase, vs. aqueous phase.

2. While the findings of this study are interesting, fundamental aspects in the methodology employed, i.e., the extent of agreement in the AMS and DESI-MS measurements, need to be addressed. I realize that additional experimental validation might be necessary:

    1) Have the authors ever tried to atomize a solution composed of, say 1:1 v/v ammonium sulfate and organic standards (e.g., succinic acid found in the aqSOA samples), into AMS and checked the measured O:C or H:C ratios?

This would be a good validation on capability of the atomizing procedure to generate equal amount of solutes in complex mixture.

2) This question might be out of the scope of the current study, but, have the authors ever used the positive mode in the nano-DESI-MS technique on the phenolic aqSOA? If so, did the positive mode measurements give the similar molecular formulas for the dominant compounds as detected by the negative mode measurements?
3) Oligomerization could potentially occur during the electrospray ionization process (e.g., formation of non-covalent dimer of terpenylic acid in the alpha-pinene SOA sample). How could the authors distinguish the oligomers produced in the actual aqueous photochemistry from the artifacts generated in the ESI process?

3. I consider the observation of ELOVCs formation during the early stage of aqueous photochemistry is one of the highlights of the present study. Could the authors comment on their formation mechanisms by comparing the differences in the chemical structures of the proposed dimers produced from OH- vs. $^3C^*$-mediated pathways?

Minor comments

1. Page 29695, Table 1: The Henry's Law constants for SYR, GUA, and PhOH need to be given here.
2. Page 29696, Table 2: Confidence intervals for the best-fit parameters need to be given.