

Interactive comment on “Identification of particulate organosulfates in three megacities at the middle and lower reaches of the Yangtze River” by X. K. Wang et al.

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RE: A point-to-point response to reviewers' comments

“Identification of Particulate Organosulfates in Three Megacities at the Middle and Lower Reaches of the Yangtze River” (acp-2015-393) by X. K. Wang, S. Rossignol, Y. Ma, L. Yao, M. Y. Wang, J. M. Chen, C. George, and L. Wang.

We are grateful to the helpful comments from JDS Surratt and M Riva, and have carefully revised our manuscript accordingly.

JDS Surratt and M Riva

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1. Although I am not a reviewer for this paper, when my Postdoctoral Scholar (Matthieu Riva) and I saw this published online in ACPD we read this with very high interest. I think the intentions of the authors are very good and this kind of data from China are highly needed in the literature.

Reply: We are very grateful to JDS Surratt and M Riva for their positive viewing of our study.

2. I strongly agree with the reviewer comments on the technical aspects they raised in their reviews. Specifically, I do want to point out that I agree that comparing seasonal and site trends really requires more filters, so these comparisons probably need to be modified with this in mind.

Reply: The manuscript will nevertheless be thoroughly edited to limit the conclusions about seasonal trends, preferentially highlighting the nature/variety of the detected OSs rather than their trends. For example, new section 3.5 is now entitled with “Comparison of OSs in the SH samples” (Page 17, Line 460). In addition, the technical aspects, and especially the LC-MS coupling, have been clarified (Page 6-9, Line 151-224). Bearing in mind the availability of instruments having resolutions better than 1 ppm, and the availability of the environmental samples as those considered here, we do believe having conducted our study according to the best available standards.

3. However, the degree of characterization provided in this manuscript is very interesting and potentially useful, especially the supplemental tables listing the detailed list of organosulfates (OSs) (including nitrated derivatives) identified from these samples. From carefully reviewing these detailed tables, it is clear that a lot of biogenic VOCs contribute to these OSs.

Reply: We gratefully thank JDS Surratt and M Riva for their support.

4. “However, the authors should be aware that a new study by Riva et al. (2015, ES&T) recently published from my group (in collaboration with Professor Eric Villenave's

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group and Professor Betsy Stone's group) revealed that organosulfur compounds (both organosulfates and sulfonates) form from the photooxidation of PAHs in the presence of sulfate aerosol. Several of the laboratory-generated PAH organosulfur compounds were identified in ambient samples collected from Pasadena, CA, USA and Lahore, Pakistan. Notably, many of the ions you report in your supplemental tables were recently characterized as sulfonates (i.e., m/z 201 [C₇H₅O₅S⁻], 215 [C₈H₇O₅S⁻], 227 [C₉H₇O₅S⁻], 229 [C₉H₉O₅S⁻]) and organosulfates (i.e., m/z 231 [C₉H₁₁O₅S⁻], 257 [C₁₀H₉O₆S⁻], 274 [C₁₀H₉O₇S⁻]) from PAH (naphthalene and 2-methylnaphthalene) oxidations in presence of sulfate aerosol (Riva et al., 2015, ES&T). In addition, we noted that many of the OSs you identified were recently observed in Riva et al. (2015, Atmos. Environ.). In that study, OSs distinct to isoprene ozonolysis were identified. Many of these OSs previously observed from isoprene ozonolysis were also identified in your supplemental tables, including m/z 181 [C₅H₉O₅S⁻], 197 [C₅H₉O₆S⁻], 199 [C₅H₁₁O₆S⁻], 213 [C₅H₉O₇S⁻], 227 [C₆H₁₁O₇S⁻], 249 [C₉H₁₃O₆S⁻], and 267 [C₉H₁₅O₇S⁻]. One lesson we learned from the isoprene ozonolysis study is that some of the OSs can have similar elemental formulas as monoterpene OSs, and thus, reporting retention times or showing extracted ion chromatograms (as suggested by one of the reviewers) will be very helpful. I also wonder if the authors agree if adding another column to their supplemental tables listing the potential VOC precursor(s) and relevant study(studies) that supports this is useful? The authors may want to add a cautionary note that even if an OS has a C₅ or C₁₀ backbone (based on accurate mass measurements), these might not necessarily come from isoprene or monoterpenes as our recent work has shown that PAHs might have similar compositions or nominal masses as these products."

Reply: This comment on your recent study on the formation of OSs, and more particularly to organo-sulfonates from PAH is of high interest regarding the determination of the nature of sulfur compounds as SOA components and the determination of their formation pathways. In our manuscript, compounds that present a number of oxygen greater than, or equal to, $4s + 3n$ (s being the number of sulfur atoms and n the number

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of nitrogen atoms) were tentatively regarded as OSs or nitrooxy-OSs, ignoring the fact that a compound with a number of oxygen atoms greater than, or equal to, $3s$ could also correspond to a sulfonate. This assumption was similarly used by Lin et al. (2012a and 2012b), for example. We think that it should be kept in the present manuscript for data processing and comparison purposes. However, specific mentions to the possibility of the presence of sulfonate groups instead of sulfate ones were added all along the text appropriately, especially when discussing compounds with high DBE values (i.e., potentially aromatic species), according to your comment.

Mention to possible PAH precursors was also added (Page 3, Line 62-64). Besides, the highly relevant cautionary note that even if an OS has a C₅ or C₁₀ backbone these might not necessarily come from isoprene or monoterpenes was introduced. Both of the previous studies, Riva et al. (2015, ES&T) and Riva et al. (2015, Atmos. Environ.), have been of course cited appropriately. We added statements such as "In the SHSD and SHSN samples, C₅ and C₁₀ were the most abundant. Isoprene and monoterpenes could be the main precursors for most of the C₅ and C₁₀ OSs (Riva et al., 2015a; Surratt et al., 2008). On the other hand, a recent work (Riva et al., 2015b) suggests that a number of observed C₁₀ OSs (e.g., C₁₀H₁₂O₇S₁) might be derived from PAHs" (Page 18, Line 495-499).

We have shown more extracted ion chromatograms in the manuscript and in the supplement, as requested by you and a number of other reviewers. Also, we have added retention times, possible precursors and corresponding references of detected OSs (new Table S3) in the supporting information.

Reference: Lin, P., Rincon, A. G., Kalberer, M., and Yu, J. Z.: Elemental composition of HULIS in the Pearl River Delta Region, China: results inferred from positive and negative electrospray high resolution mass spectrometric data, *Environmental science & technology*, 46, 7454-7462, doi: 10.1021/es300285d, 2012a. Lin, P., Yu, J. Z., Engling, G., and Kalberer, M.: Organosulfates in humic-like substance fraction isolated from aerosols at seven locations in East Asia: a study by ultra-

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highresolution mass spectrometry, *Environmental science & technology*, 46, 13118-13127, doi: 10.1021/es303570v, 2012b. Riva, M., Budisulistiorini, S. H., Zhang, Z., Gold, A., and Surratt, J. D.: Chemical characterization of secondary organic aerosol constituents from isoprene ozonolysis in the presence of acidic aerosol, *Atmos. Environ.*, doi:10.1016/j.atmosenv.2015.06.027, 2015a. Riva, M., Tomaz, S., Cui, T., Lin, Y.-H., Perraudin, E., Gold, A., Stone, E. A., Villenave, E., and Surratt, J. D.: Evidence for an Unrecognized Secondary Anthropogenic Source of Organosulfates and Sulfonates: Gas-Phase Oxidation of Polycyclic Aromatic Hydrocarbons in the Presence of Sulfate Aerosol, *Environ. Sci. Technol.*, 49, 6654-6664, doi:10.1021/acs.est.5b00836, 2015b.

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