Referee comment on "Multiple pathways for the formation of secondary organic aerosol in North China Plain in summer" by Yifang Gu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-573-RC1, 2022

General comments:

The paper titled “Multiple pathways for the formation of secondary organic aerosol in North China Plain in summer” by Gu et al. reported an summer field observation in Handan City, in which four types of SOA were resolved using the PMF method dealing with the OA mass spectra data from a soot particle long time-of-flight aerosol mass spectrometer. In addition, the variations and evolution processes of so-called SOA factors were discussed and their formation pathway were then deduced. Although a series of similar studies using AMS data had been reported in NCP previously, this study provided a more detail source appointment results in distinguish SOA as freshly (less-oxidized) and aged (more-oxidized) factors, and further directly associated with the formation pathway (photochemistry and aqueous-phase). With this, a better understanding of ambient SOA formation and aging in complex pollution with high oxidation capacity were gained. The manuscript was well written and presented clearly. Therefore I recommend the publication of Gu et al. work after some issues were clarified and revised.

Specific and technical comments:

- Line 167-170. The new named four SOA factors are interesting, that different from previous studies using same AMS data set resolved by PMF. But the identification of those SOA fators were missed here, or a brief description but not enough appeared in the end of section 3.1. I think the identification of SOA factor is the most important and the foundation of this study, thus a detail description should be provided here. For example, why do the authors directly name the OOA factor as photochemistry and aqueous-phase formed? What the difference between the primary-related SOA and
CCOA, both of which showed pronounced peaks of PAH ions?

- Line 260-262. The transformation processes of POA and fresh SOA factor to phochem-SOA is interesting, it deserve more discussions here. Exploring the diurnal pattern of these factors during a special episode would be a choice, such as that conducted in Li et al. 2020. https://doi.org/10.1016/j.atmosenv.2019.117070.
- Line 277-282. The aqueous-phase chemistry may also contributed to the fresh-SOA, but if so it is unclear what the difference of aqueous-phase in fresh-SOA and aq-SOA?
- Line 289-290. It is subjective to conclude that the photochemistry is more efficient in elevating the oxidation degree of OA, as the correlations were analyzed during different periods (P2 and P3), during which other factors like primary emissions and transportation would be different and also effect the O:C ratio of OA.
- Line 308-310. It is unclear where the photochemistry formation of SOA occurred. Please clarify it and revise this sentence.
- Line 351-353. I do not think the transformation of POA to SOA could be deduced based solely on the negative correlation of each other. In fact, as showed in Fig 7, the negative correlation between phochem-SOA and POA would be expected, as the formation period of phochem-SOA usually occurred during the noontime when the boundary layer was much developed, while the POA usually decreased via horizontal and vertical diffusion. It is also supported by the better correlations in P2, which defined as high-Ox period and also has better diffusion conditions. Please clarify it.