We thank the reviewers for their comprehensive and insightful comments on our manuscript, which have greatly improved the manuscript. We have addressed all the comments reviewers raised in the revision. According to reviewers' comments, the main revisions we made include:

1. We have incorporated the suggestions provided by the reviewers to improve the introduction and discussion of the measurement techniques used in our study. We have elaborated on the technical details and methodology.

2. We have carefully reviewed the manuscript for editorial and grammatical errors and corrected these issues to improve the readability of our work.

Reviewer 1:

General comments:

The author used the tandem system of DMA-CCN coupled with SP2 to directly monitor the droplet activation diameter (D50) and activation fraction of BCc in ambient environment. Further, the author also quantifies activation properties of BC on a time scale, and found BCc from anthropogenic sources can readily serve as CCN at a relatively low SS. I believe that the topic is interesting and it could be useful to the scientific community. However, some modifications are needed before it can be accepted.

We thank the reviewer for the positive comments and suggestions. We have carefully considered your feedback and have made the following revisions to our manuscript.

Major comments:

1. The author calculates the photochemical age by the toluene/benzene ratio. However, even during the day, toluene can be affected by air mass transport, local emissions, or solvent volatilization, which introduces considerable uncertainty to the calculation. Can the author give more information support your result?

We acknowledge the reviewer's concern regarding the potential uncertainties in calculating the equivalent photochemical age (t_{age}) due to the mixing of air masses. However, this methodology, despite its limitations, has been validated as a reasonable metric to evaluate the photochemical age in the region with slimmer and stable source emissions. The influence of adding a significant proportion of local fresh air does affect the measured toluene/benzene ratio, yet it concurrently indicates that such air masses are relatively less aged compared to those that have undergone regional transport. The application and the uncertainty of using t_{age} has been given in our prior publication (Wu et al., 2022), which we have directly applied in this study. We have added the related discussions in the revision.

Line 188-206:

"The mass spectra of VOCs were measured using the PTR-TOF-AMS, calibrated with the CH3COCH4+ (m/z 59.0490) and H3O+ (m/z 21.0226), following the procedures

described by Bruns et al. (2016). The equivalent photochemical age (t_{age}), a critical factor for assessing the duration of atmospheric photochemical reaction, is derived from comparing the ratios of two VOCs with different OH radical reaction rates, acknowledging that species more reactive with OH diminish more rapidly as photochemical aging increases (Yuan et al., 2012). Despite uncertainties arising from the mixing of fresh emitted and aged air masses, this method provides valuable insights into atmospheric photochemical processing (Parrish et al., 2007). In this study, toluene and benzene were chosen for their strong correlation and differing reaction rates with OH, and expressed as:

$$t_{age} = \frac{1}{[OH](k_{toluene} - k_{benzene})} \times [\ln(\frac{[toluene]}{[benzene]})_0 - \ln\left(\frac{[toluene]}{[benzene]}\right) \quad (6)$$

where [OH] is the ambient average OH concentration (2×10^6 molecule cm^{-3}) obtained from the reanalysis product (available from the European Center for Medium Range Weather Forecasts: Atmospheric Composition Reanalysis 4), consistent with previous observation in Beijing (Liu et al., 2018). $k_{toluene}$ and $k_{benzene}$ is the reaction rate with OH of toluene (5.63×10^{-12} cm^{-3} $molecule^{-1}$ s^{-1}) and benzene (1.22×10^{-12} cm^{-3} $molecule^{-1}$ s^{-1}), respectively. $(\frac{[toluene]}{[benzene]})_0$ is the ratio of freshly emitted toluene and benzene, and the value was determined to be 2.27± 0.27 according to the maximum toluene/benzene ratio during the experiment. $\frac{[toluene]}{[benzene]}$ is the ratio of measured toluene and benzene in the atmosphere. The calculation of t_{age} was performed only during daytime ensure it reflects the photochemical process. The dataset of t_{age} in this study has been successfully tested to determine the photochemical reaction or production rates of secondary OA, with further details on the calculation of [OH] and $\frac{[toluene]}{[benzene]})_0$ available in Wu et al., (2022). "

2. Lines 233-238, As far as I know, the chemical composition on BC was different with that of all particles, which may lead to the deviation of the κ of BC calculated based on this method, can the author further elaborate on this?

Here we consider the compositions of substances either internally or externally mixed with BC are similar, which are all from the AMS measurement. This approximation has been used in many previous studies (Liu et al., 2013; Ohata et al., 2016) for the best estimate for the coatings on BC. Though some studies found the coatings on BC contained a higher OA fraction than BC-free particles (Wang et al., 2020). Considering the OA has a lower κ than other inorganic salt, this may lead to an overestimation of κ of BCc. These discussions are now added in the revision.

Line 247-250:

"Many studies assumed the same components between BC coatings and other substances externally mixed with BC (Liu et al., 2013; Ohata et al., 2016), as consistent with the assumption in this study. However, the coatings on BC may contain a higher OA fraction than other BC-free particles (Wang et al., 2020), which means the current

calculation may give a higher estimation of κ_{BCc}."

Specific comment:

Line 196: xxx is the ration of measured ……., may be ratio? Rather than ration.

Corrected.

Line 202-203:

"$\frac{[toluene]}{[benzene]}$ is the ratio of measured toluene and benzene in the atmosphere."

Reference:

Liu, D., Allan, J., Whitehead, J., Young, D., Flynn, M., Coe, H., McFiggans, G., Fleming, Z. L., and Bandy, B.: Ambient black carbon particle hygroscopic properties controlled by mixing state and composition, Atmos. Chem. Phys., 13, 2015-2029, 10.5194/acp-13-2015-2013, 2013.
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