Spherical tarballs form through chemical and physical evolution of primary organic particles in biomass-burning smoke

*Kouji Adachi[1]

1. Meteorological Research Institute

Biomass burning is an urgent issue for the regional environment and global climate. Recently, large-scale wildfires have occurred in Australia, Brazil, the United States, and elsewhere, and large amounts of gases and aerosol particles have been released into the atmosphere. Organic matter is dominant in aerosol particles from biomass burning and influence the climate by scattering/absorbing light and becoming cloud condensation nuclei. Within relatively aged smoke (a few hours after emission), the spherical organic particles, named “tarball”, are of interest because of their abundance and optical property. Tarballs can be identified based on their spherical shapes on the substrate observed using, for example, transmission electron microscopy (TEM). Studies assumed various tarball formation processes but have not yet confirmed them. This study aims to understand the occurrence and formation of tarballs in biomass burning smoke using TEM.

Biomass burning samples were collected on TEM grids during the BBOP campaign 2013 using the G-1 aircraft in the northwestern United States. During the BBOP campaign, the mass fraction of tarballs was estimated to be ~30% in smoke from biomass burning, and the refractive index of tarball was estimated to be 1.56-0.02i (Sedlacek et al., 2018). The mode diameter of tarball was 223nm (Adachi et al., 2019). In addition, chemical and physical evolution of organic matter from biomass-burning smoke and the formation of tarball particles were observed. When organic particles were fresh, less than 1 hour from the emissions, organic matters had low viscosity and surface tension, resulting in spread on the substrate due to the impact when collected. Fresh organic matters contained potassium salts as inclusions. Within samples collected several hours after the emissions, organic particles increased their viscosity and become rounded on the substrate. In addition to the increase in sphericity, the weight percentage of nitrogen and oxygen relative to potassium, which is a conserved tracer, was increased. The observation suggested that chemical reactions involving O and N within primary organic maters change the particle viscosity and surface tension, resulting in tarballs. Currently, the tarball formation hypothesis is being tested using biomass burning samples collected during the FIREX-AQ campaign. The campaign was conducted from July to September 2019 in the United States using a NASA DC-8 aircraft. During the campaign, both biomass burning smokes from wildfire and agricultural fire were observed. Tarball particles had similar appearances with those from the BBOP, and further TEM analyses are being processed.

References

Adachi K., Sedlacek A.J., Kleinman L., Springston, S.R. Wang J., Chand D., Hubbe J.M., Shilling J.E., Onasch T.B., Kinase T., Sakata K., Takahashi Y., Buseck P.R., Spherical tarball particles form through rapid chemical and physical changes of organic matter in biomass-burning smoke, Proceedings of the National Academy of Sciences 116 (39), 19336-19341, 2019.

Sedlacek II, A. J., P. R. Buseck, K. Adachi, T. B. Onasch, S. R. Springston, and L. Kleinman, Formation and evolution of tar balls from northwestern US wildfires, Atmospheric Chemistry and Physics, 18(15), 11289-11301, 2018.

Keywords: biomass burning, aerosol, observation

