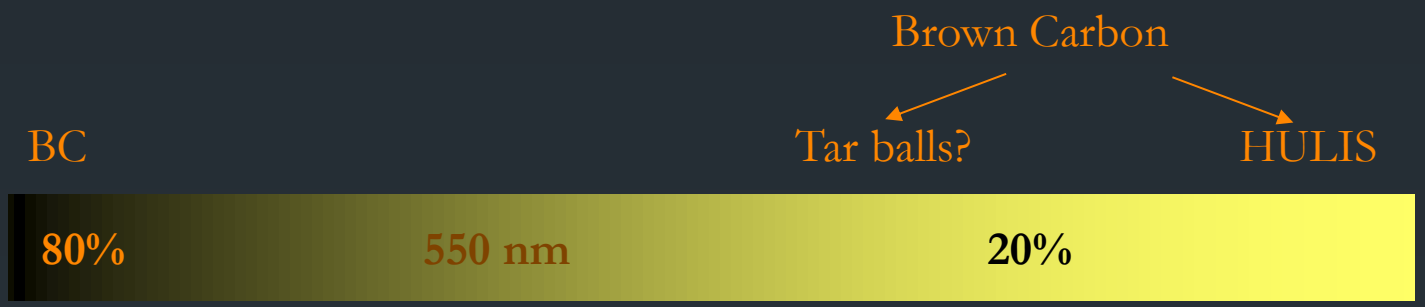
Atmospheric Tar balls—The dark side of brown carbon

András Hoffer, Ádám Tóth, Ilona Nyirő-Kósa, Mihály Pósfai, András Gelencsér

University of Pannonia, Veszprém, Hungary
MTA-PE Air Chemistry Research Group, Veszprém, Hungary

GLOBAL SIGNIFICANCE OF BROWN CARBON

Light-absorbing carbon (Andreae & Gelencsér, 2006)



(Chung et al., 2012)

www.pnas.org/cgi/doi/10.1073/pnas.1203707109 **Proceedings of National Academy of Sciences, 2012**

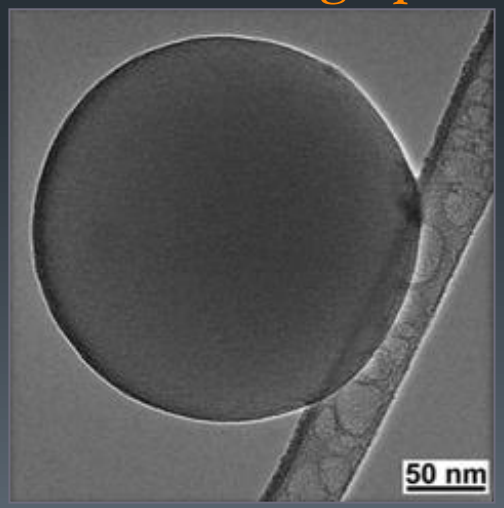
Observationally constrained estimates of carbonaceous aerosol radiative forcing

Chul E. Chung[a,1], Veerabhadran Ramanathan[b], and Damien Decremer[a]

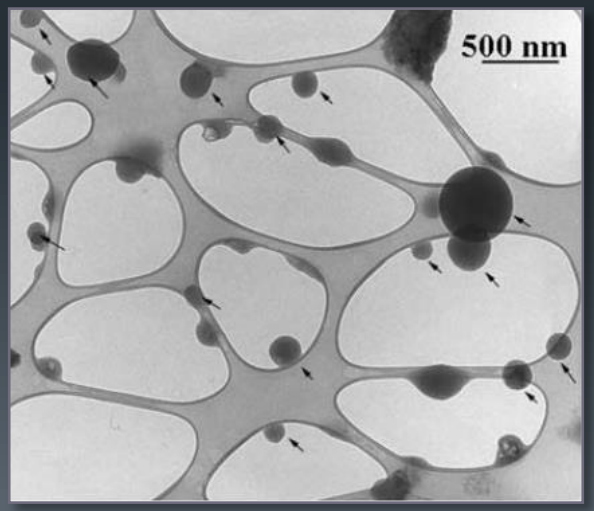
This study identifies the global importance of BrC, which is shown to contribute about 20% to 550-nm CA solar absorption globally. Because of the inclusion of BrC, the net effect of OM is close to zero and the CA forcing is nearly equal to that of black carbon.

ATMOSPHERIC TAR BALLS

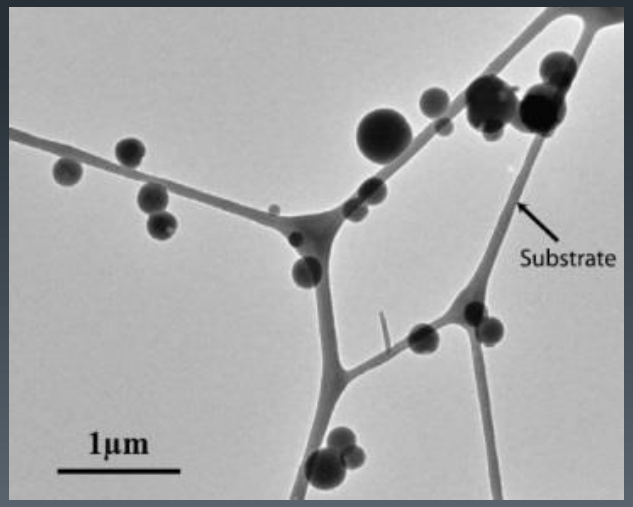
- **Abundant in biomass smoke plumes**
  (Pósfai et al., 2003, 2004; Adachi és Buseck, 2008; China et al., 2013)
- **Perfectly spherical**
- **Refractory (no damage under electron beam)**
- **Typical size 50–500 nm**
- **Externally mixed**
- **Homogeneous contrast in TEM**
- **C/O ratio 6–10**
- **Lack of graphene microstructure**



Alexander et al., (2008)

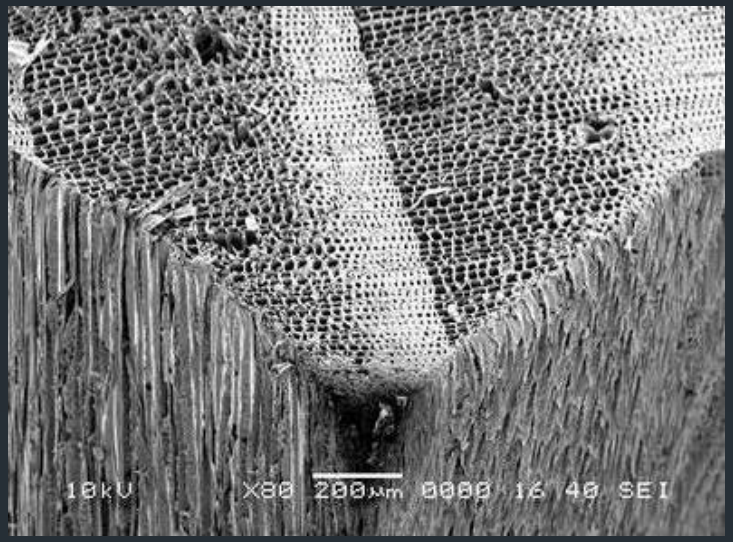


Pósfai et al., (2003)

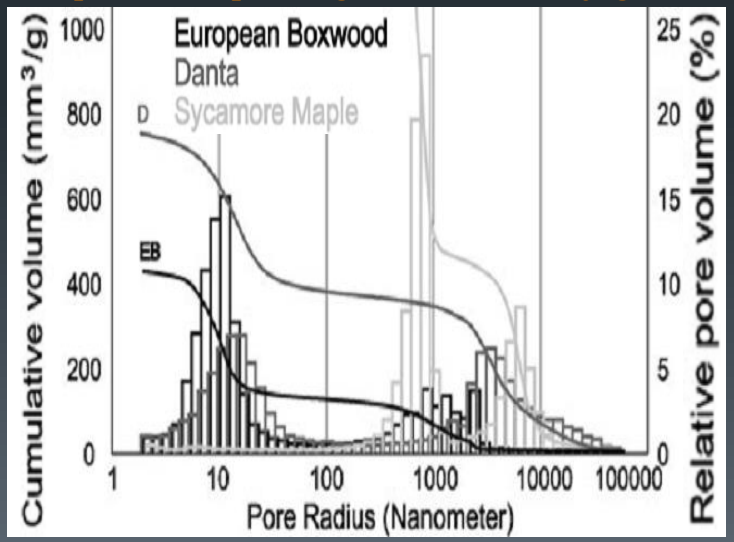


Adachi and Buseck (2011)

Hypothesis for tar ball formation



http://hu.wikipedia.org/wiki/Fa_%28anyag%29



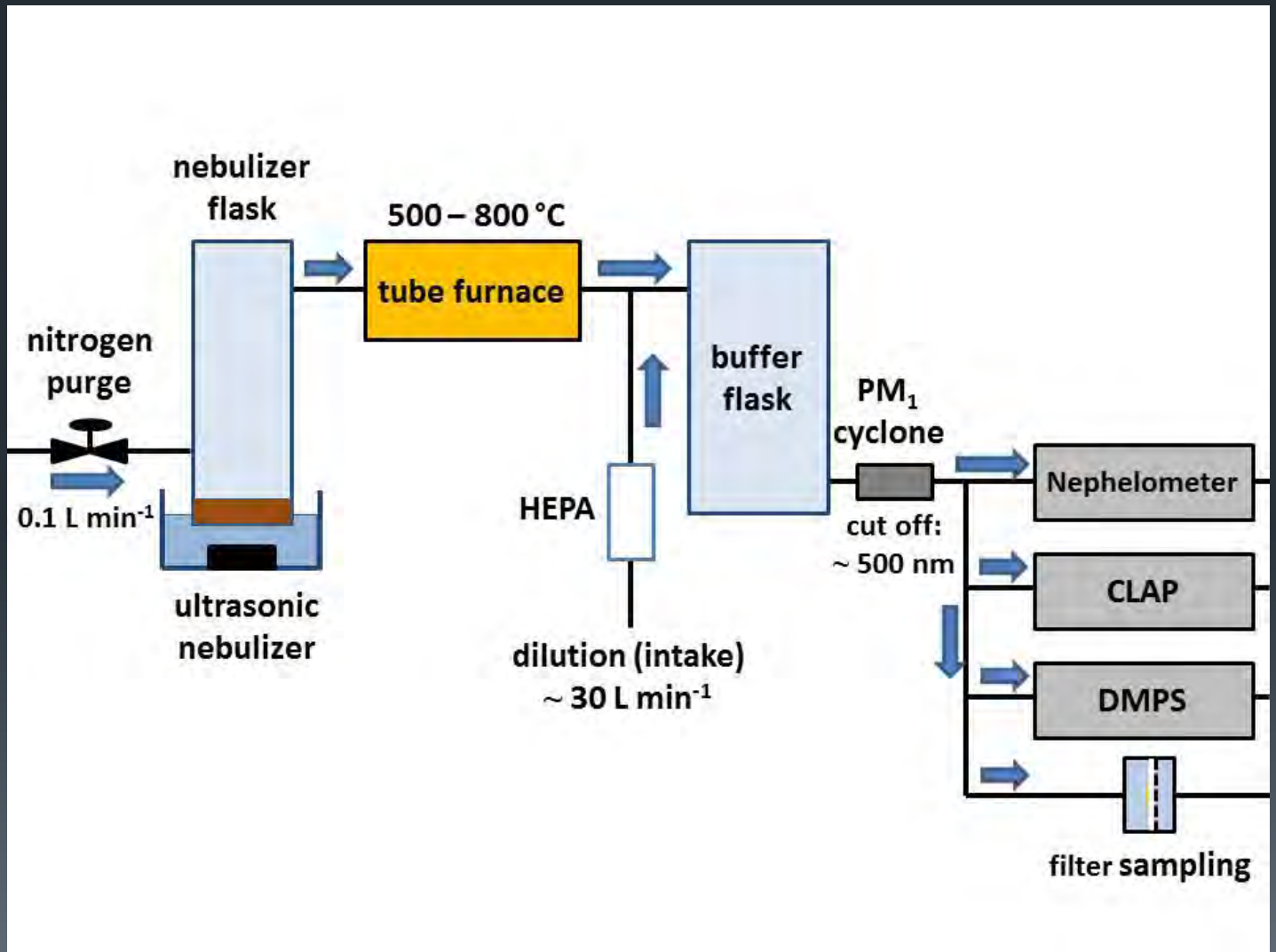
Plötze and Niemz (2010)

- **Liquid tar droplets ejected directly from biomass pores**
- **Charring/polymerization in the fire zone**

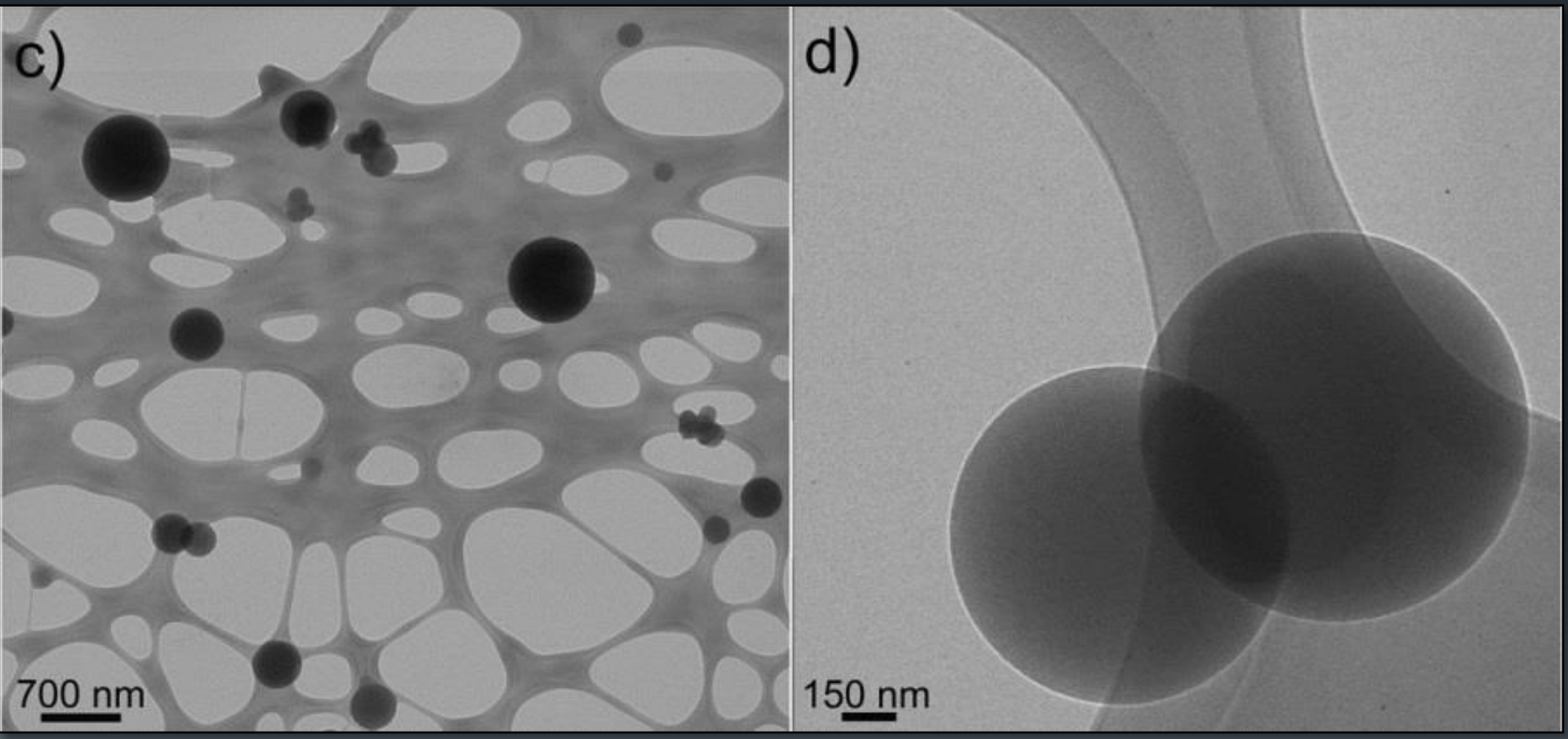
Liquid tar preparation

- Dry distillation of European Turkey oak (*Quercus cerris*) in a Kjeldahl flask
- ~ 170 g wood chops of ~ 25×10×10 mm size
- Heating at ~ 25 °C min^{-1} up to 530 °C
- 40 ml liquid tarry condensate

Experimental setup for tar ball generation from tar emulsions



Morphology of lab-generated tar ball particles at 600 °C



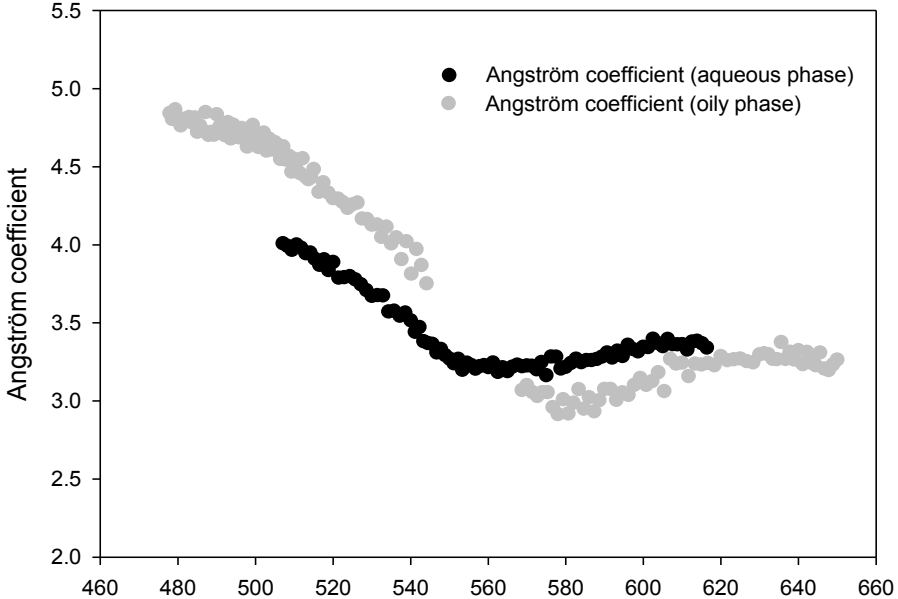
Checklist for tar ball properties

Attributes of atmospheric tar balls	
Perfectly spherical	✓
Refractory (no damage under electron beam)	✓
Size range 50–500 nm	✓
Externally mixed	✓
Homogeneous contrast in TEM	✓
C/O ratio 6–10	✓
Lack of graphene microstructure	✓

Measured optical properties of tar balls

Mass absorption coefficients: 0.8–3.0 $m^2 g^{-1}$ (550 nm)

BC ~7 $m^2 g^{-1}$ (Clarke, 2004); HULIS ~0.032 $m^2 g^{-1}$ (Hoffer, 2006)



Derived refractive index of tar balls

Laboratory generated tar balls: 1.84−0.21*i*

Carbon spheres from ACE-Asia: 1.67−0.27i (Alexander, 2008)

CONCLUSIONS

- TBs lack fundamental properties of BCs (Petzold et al., 2013)
- Yet TBs are suprisingly close to BC in absorption efficiency
- TBs may be even more significant contributors to light absorption in ABCs than previously thought

THANK YOU FOR YOUR ATTENTION

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Atmospheric Chemistry and Physics

Atmospheric tar balls: aged primary droplets from biomass burning?

A. Tóth[1], A. Hoffer[2], I. Nyirő-Kósa[2], M. Pósfai[1], and A. Gelencsér[1,2]

[1]Department of Earth and Environmental Sciences, University of Pannonia, Vesz
[2]MTA-PE Air Chemistry Research Group, Veszprém, P.O. Box 158, 8201, Hung

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Atmospheric Chemistry and Physics Discussions

Light absorption properties of laboratory generated tar ball particles

A. Hoffer[1], A. Tóth[2], I. Nyirő-Kósa[1], M. Pósfai[2], and A. Gelencsér[1,2]

[1]MTA-PE Air Chemistry Research Group, Veszprém, P.O. Box 158, 8201, Hungary
[2]Department of Earth and Environmental Sciences, University of Pannonia, Veszprém, P.O. Box 158, 8201, Hungary

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Correspondence to: A. Gelencsér (gelencs@almos.uni-pannon.hu)

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