Pollen Rupture and Wall Deposition in Turbulent Pipe Flow

#334

L. Haya[1], S. Van de Mosselaer[1], H. Shakir[1], S. Kelly[1], R. Friedrich[1], A. Belanger[1], J. Yang[1], W.H. Yang[1], E. Matida[2]
[1]Red Maple Trials Inc., Ottawa, ON., Canada
[2]Carleton University, Ottawa, ON., Canada
lhaya@redmapletrials.com
www.redmapletrials.com

Rationale

- Ruptured pollen can release micron-sized antigen-carrying granules which penetrate the lower respiratory tract & induce asthma.
- The mechanical rupture of pollen (e.g. due to impaction) is less understood than rupture from osmotic swelling (e.g. in 'thunderstorm asthma').
- The behaviour of ragweed, birch, and Timothy grass pollen in turbulent pipe flow was studied to minimize rupture and deposition losses in our novel pollen exposure chamber.

Methods

- A conveyance setup was used to assess *pollen rupture* & determine the *critical & cleaning velocity* of the pollen.
  - *Critical velocity*: The velocity at which pollen re-entrainment commenced.
  - *Cleaning velocity*: The velocity at which no pollen was visible in the pipe following re-entrainment.
- Pollen was loaded and aerosolized in a mixing box, from which it flowed through a 2 m clear acrylic tube (D = 2.54 cm) and settled in a collection box (***Fig. 1***).
- Pollen was conveyed in dry air (RH < 5%) at velocities between 1.4 m/s and 18 m/s (1.5 – 19.33 CFM; Re 2,263 – 29,101).
- Deposition was imaged in a 20 cm test section of the acrylic tube, 145 cm downstream of the inlet to ensure the flow was fully developed.
- Pollen was collected on glass slides at the bottom of the collection box & examined under magnification to assess rupture.

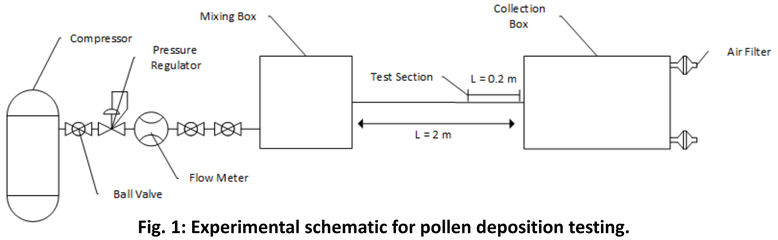


Fig. 1: Experimental schematic for pollen deposition testing.

We studied the **re-entrainment** & **rupture** of **pollen** in **pipe flow** to minimize rupture & losses in our **allergen exposure chamber (AEC).**

Velocities were found which **cleaned** pollen from the pipes & enhanced **efficiency** of our AEC.

Image: Ragweed x500 SEM

Results

- The *critical velocity* for birch and ragweed was found to be from ***5-6 m/s*** and ***4-5 m/s*** for grass, and the *cleaning velocity* for birch, grass, and ragweed was found to be from ***10-11 m/s*** (***Fig. 2***).

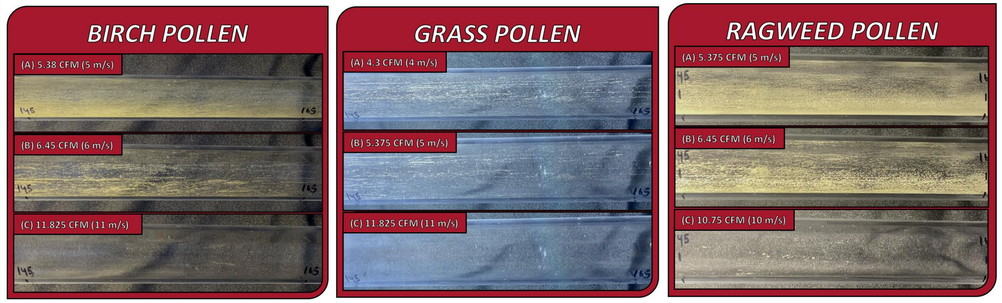
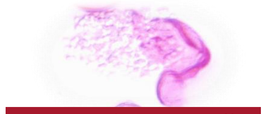


Fig. 2: Imaging of pipe deposition at various velocities.

- Preliminary results revealed that grass was the most susceptible to rupture, even at relatively low flow rates (***Fig. 3A***).
- Birch & ragweed did not show rupture, relative to baseline, at higher flow rates (***Fig. 3B, 3C***).



Ruptured Grass Pollen

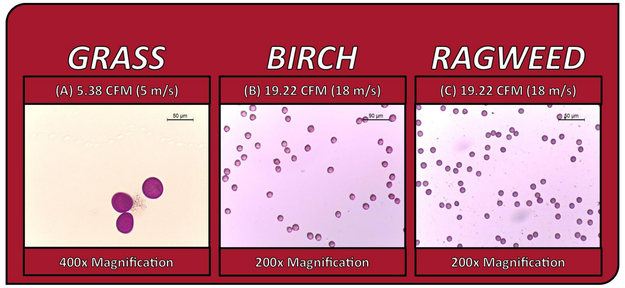


Fig. 3: Microscopic images of pollen samples collected on slides placed 30 cm from the collection box inlet.

Conclusions

- Wall deposition increased with increasing velocity up to a maximum, beyond which it decreased due to re-entrainment.
- Mechanical stresses caused rupture of grass pollen grains. Ragweed & birch pollen were more resilient and did not show rupture at high flow rates.
- Ongoing investigation will refine flow control to test additional velocities & further characterize & quantify mechanical rupture through supplemental imaging.

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