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Flame Development in Pulverised Biomass.

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Abstract

Pulverised biomass is a significant source of carbon neutral renewable electricity and hence plays an important role in carbon reduction strategies. Pulverised biomass is burned either co-fired with coal or increasingly in the UK as 100% pulverised biomass, due to fiscal incentives to do this. The particle size fed to the burners is relatively coarse with a low proportion <75 μm and most being in the 75 - 1000 μm size range. There is little information on the flame propagation in clouds of coarsely pulverised biomass and this work was carried out to show coarse biomass could burn in a similar way to fine biomass but with slower flame speeds.

There is little in the open literature on flame propagation and explosion risk for fine or coarse biomass particles and this work presents some results using the Hartmann dust explosion tube with high speed photography. The equipment was fitted with a vertical line of three thermocouples (red lines) to detect the flame arrival and determine the mean flame speed as a measure of the mixture reactivity. A second reactivity parameter was the initial rate of pressure rise prior to the vent bursting at the end of the tube. Lycopodium, and oak were investigated. Lycopodium powder is a pollen biomass that is ultra-fine. Oak sawdust was investigated for a fine $\leq 63\mu\text{m}$ fraction and for a coarser fraction. The lycopodium flame propagation is shown in Fig. 1. Similar results were obtained for oak milled to $<63\mu\text{m}$.

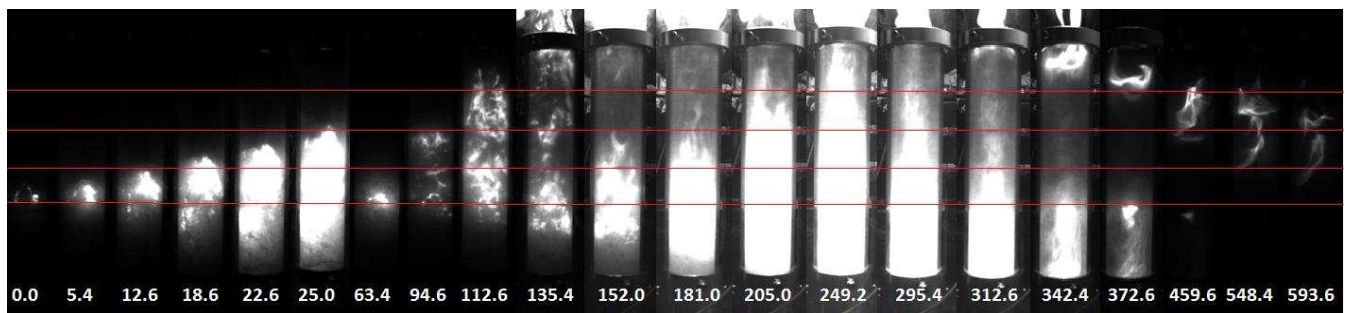
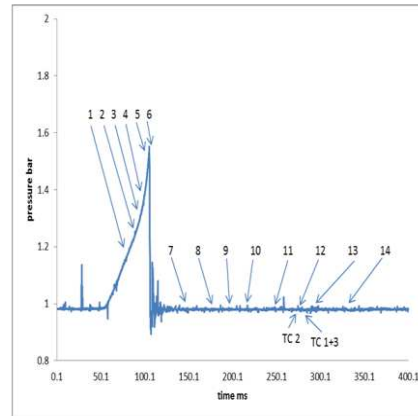
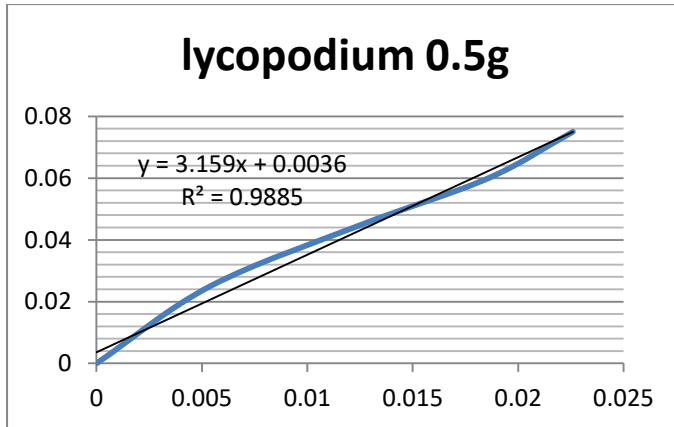


Figure 1 Lycopodium powder flame propagation ($\phi=1= 122.1\text{g/m}^3$) 0.5g , 375g/m^3 , $\phi= 3.07$.



The flame speeds before the vent burst for the two materials were 3.5 m/s for lycopodium and 3.0 m/s for oak. The initial flame front before the vent has burst was the only flame that propagated at the rich injected concentration. Once the vent burst the flame exited the top of the Hartmann tube and then air entered the tube as the products of the first flame propagation cool and this caused a reduction in pressure, which created a vacuum that drew air into the tube. As the initial mixture was rich there was fuel left in the tube that caused a second flame in the tube. This flame was slightly faster at 3.8 m/s than the first flame. The flame arrival times at the thermocouples occurs after the vent has burst and the second flame speed is measured by the thermocouples. For coarser oak dusts the flame was more fragmented and propagated more slowly, but there was still a clear explosion risk.

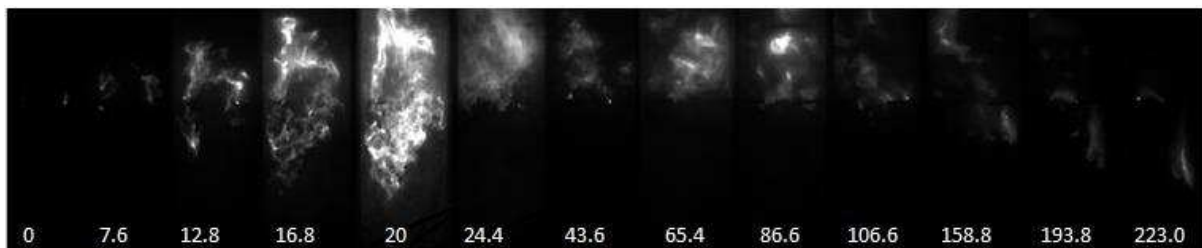
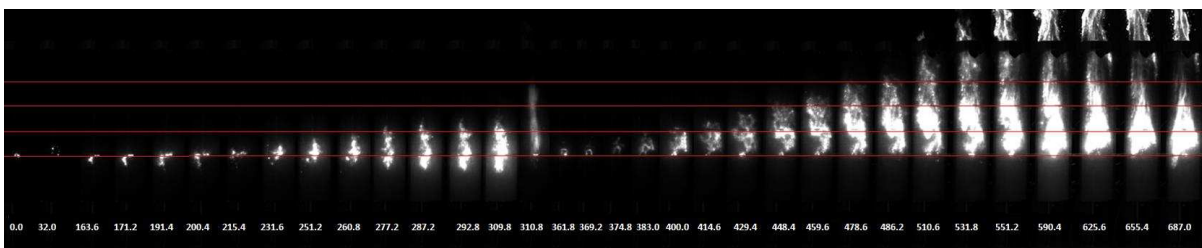
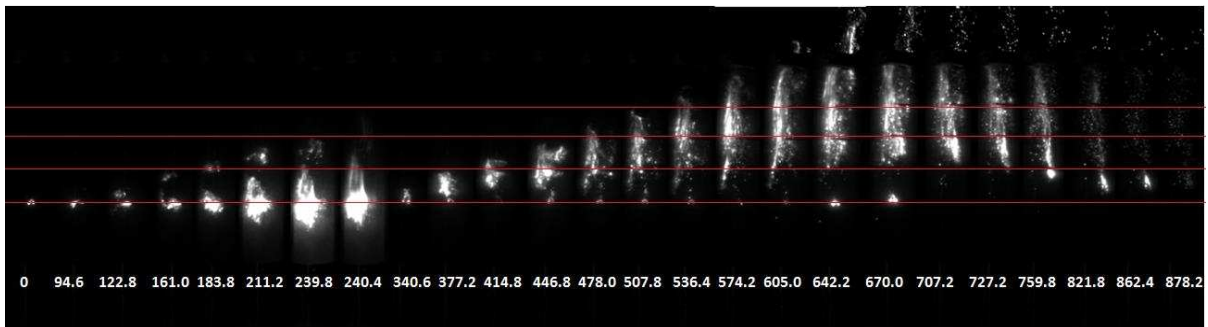
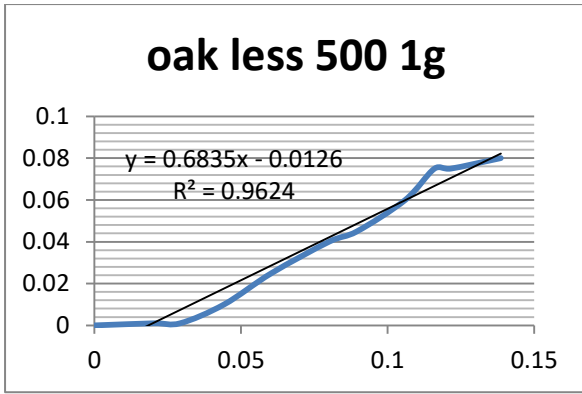


Figure 2 Lycopodium powder flame propagation ($\phi=1= 122.1\text{g/m}^3$) 0.05g, 37.5g/m^3 , $\phi=0.307$

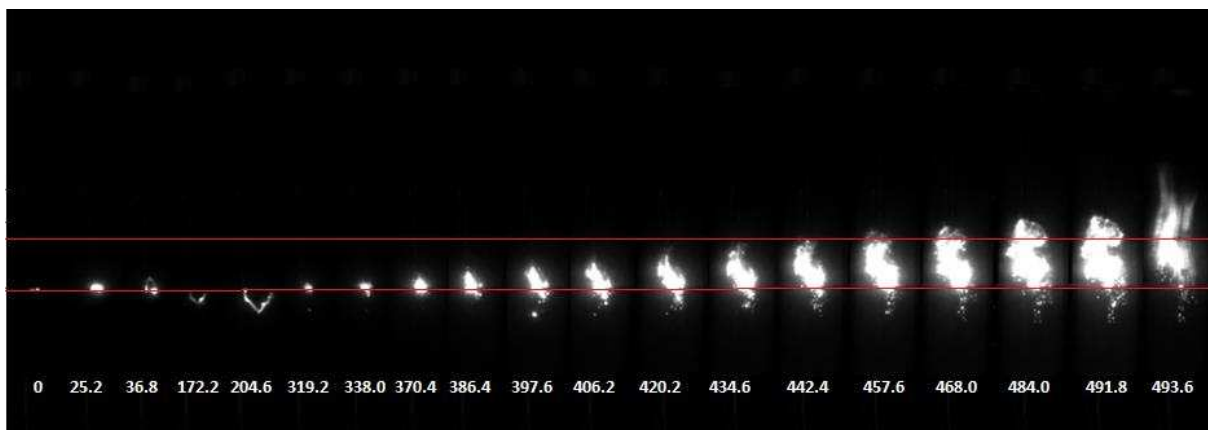
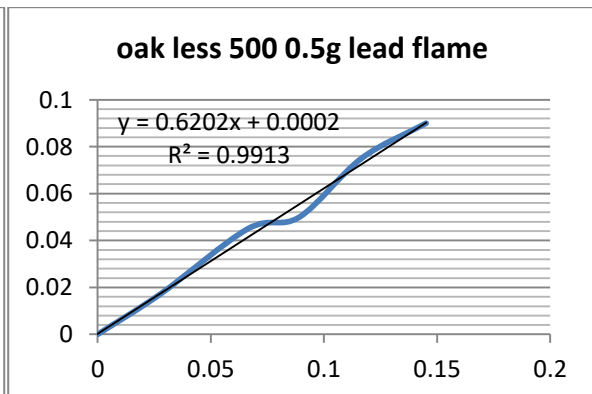
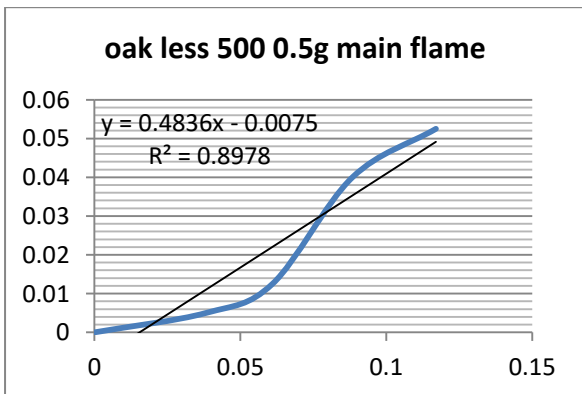
OAK less 500



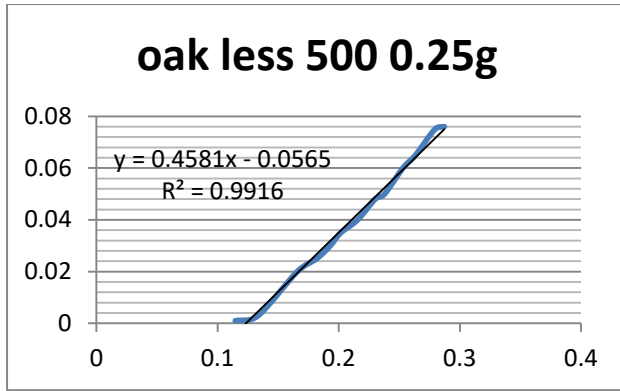
Oak less than $500\mu\text{m}$ ($\phi=1= 218.9$) 1 g, 750g/m^3 , $\phi=3.44$



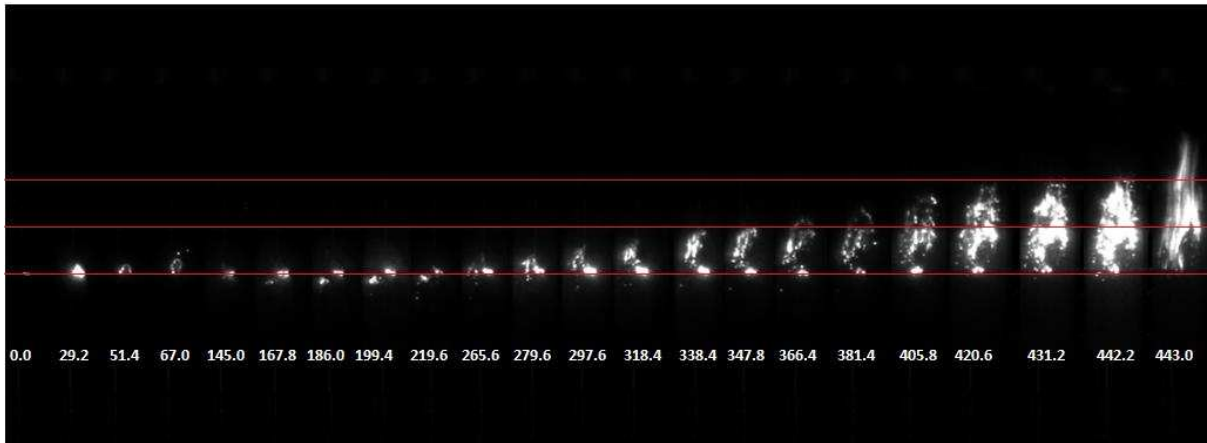
Oak less than 500 ($\emptyset=1=218.9$) 0.5 g, 375g/m^3 , $\emptyset=1.71$



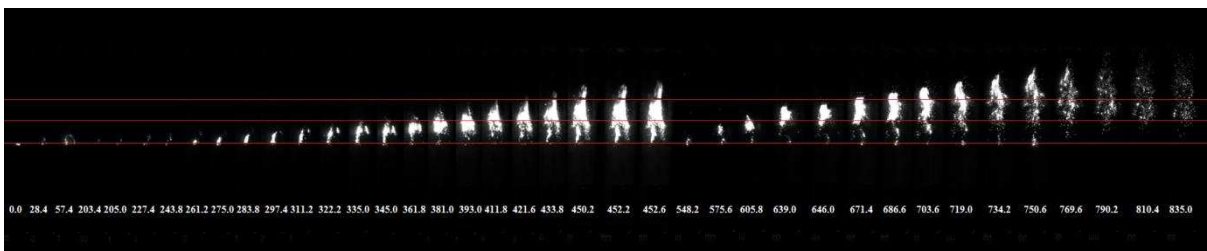
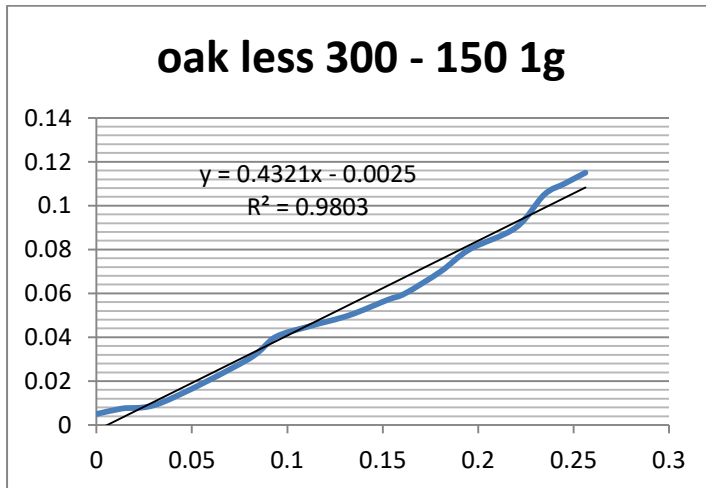
Oak less than 500 ($\emptyset=1=218.9$) 0.25 g, 187.5g/m^3 , $\emptyset=.86$



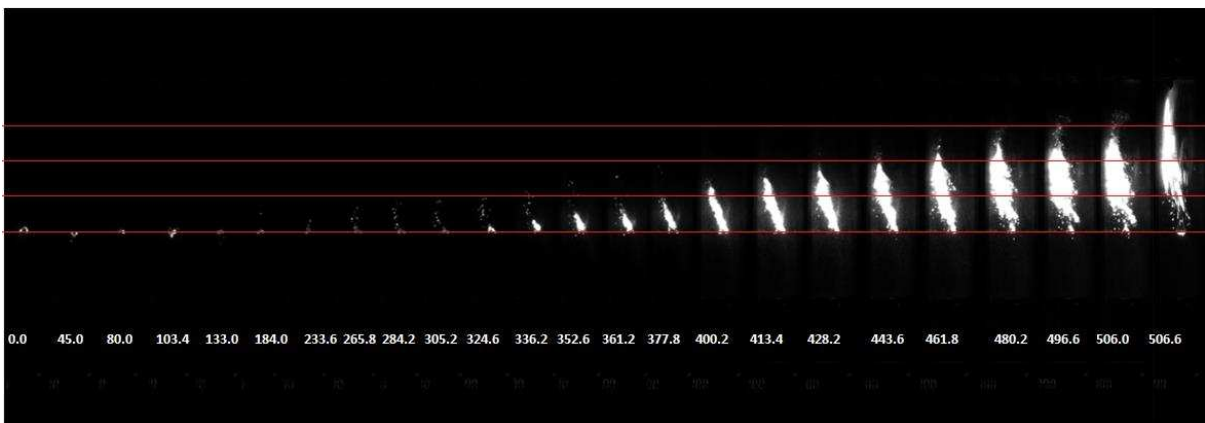
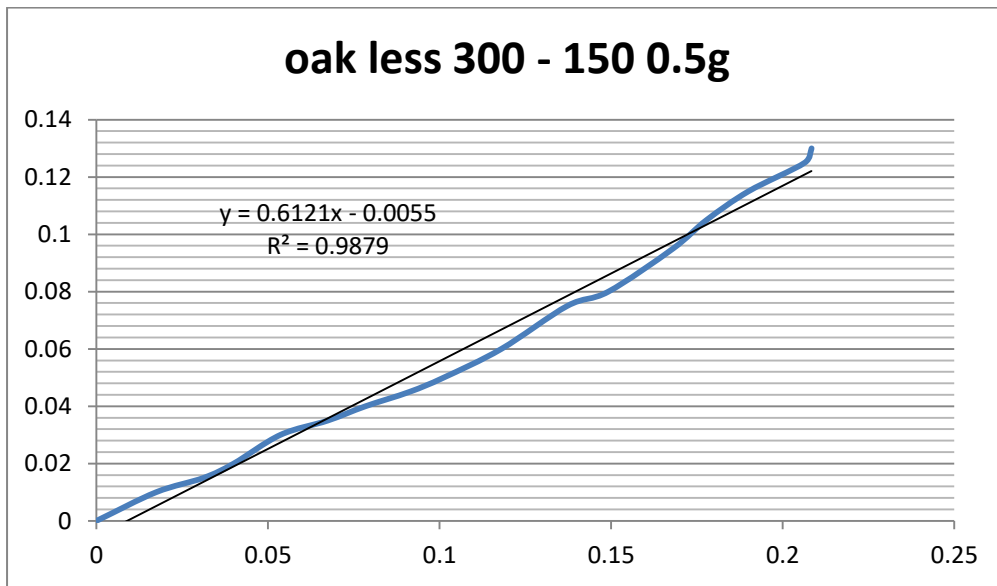
OAK 300 -150



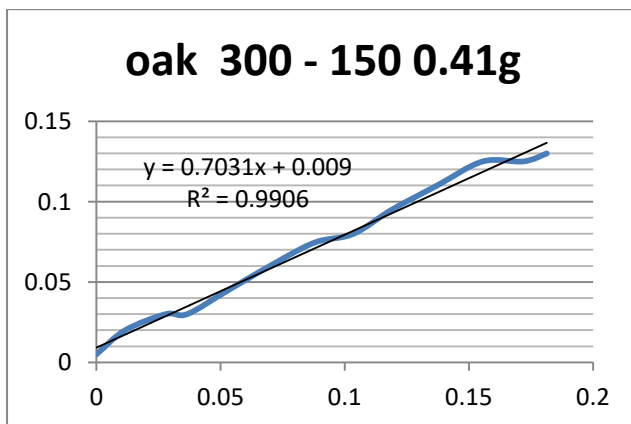
Oak 300 -150 μm ($\phi=1=218.9$) 1 g, $750\text{g}/\text{m}^3$, $\phi=3.44$



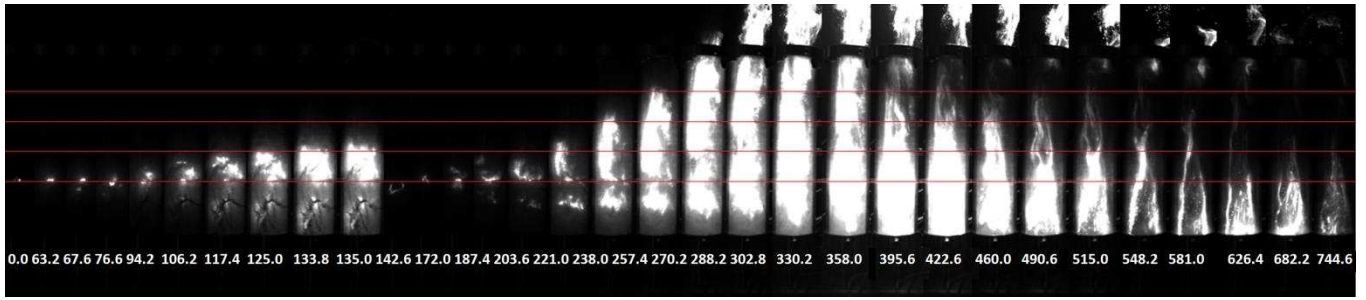
Oak 300 -150 μ m ($\emptyset=1= 218.9$) 0.5 g, 375g/m³, $\emptyset=1.71$



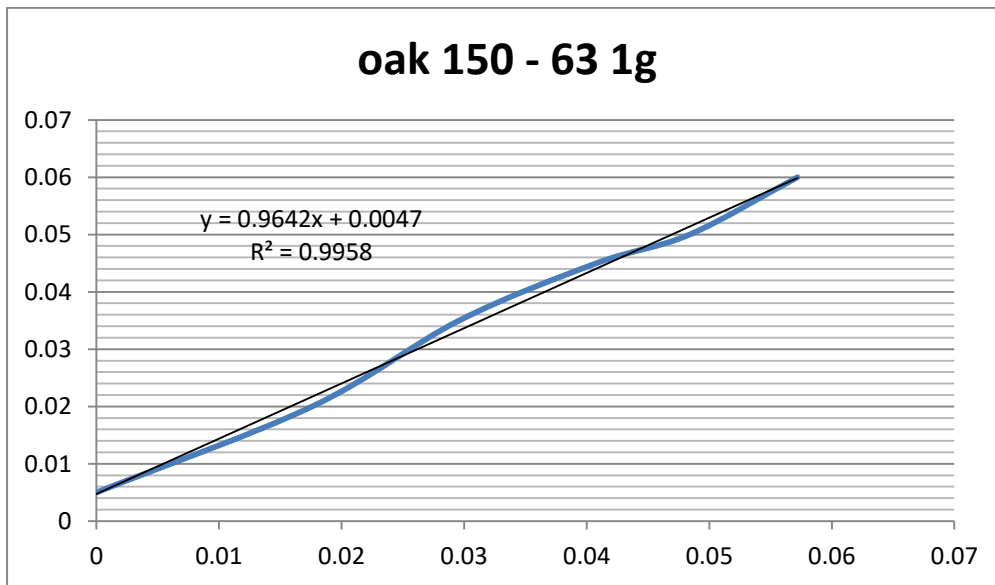
Oak 300 -150 μ m ($\emptyset=1= 218.9$) 0.41 g, 300g/m³, $\emptyset=1.37$



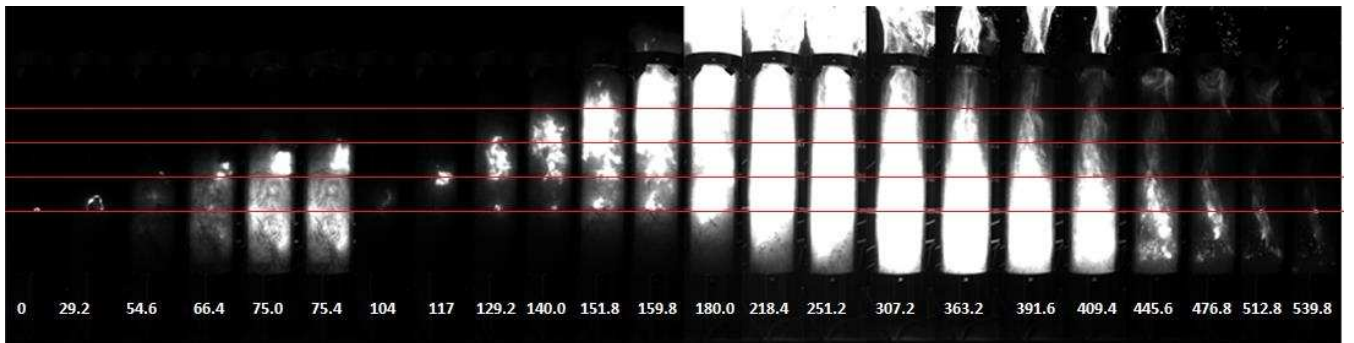
OAK 150 - 63



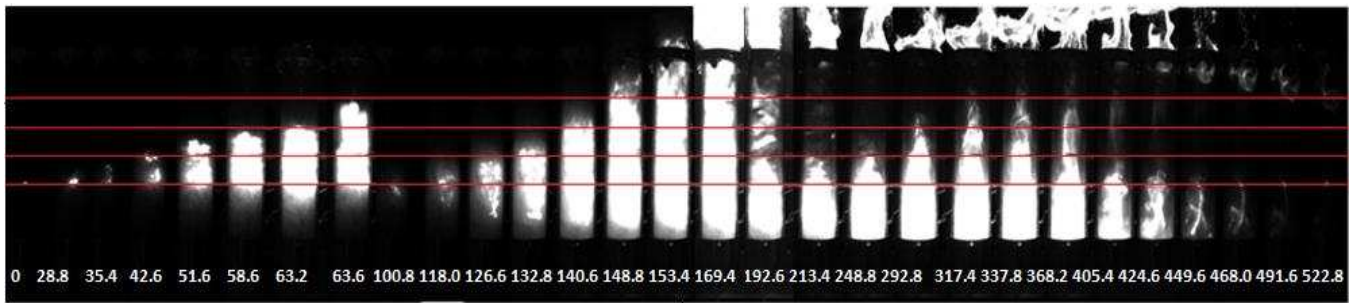
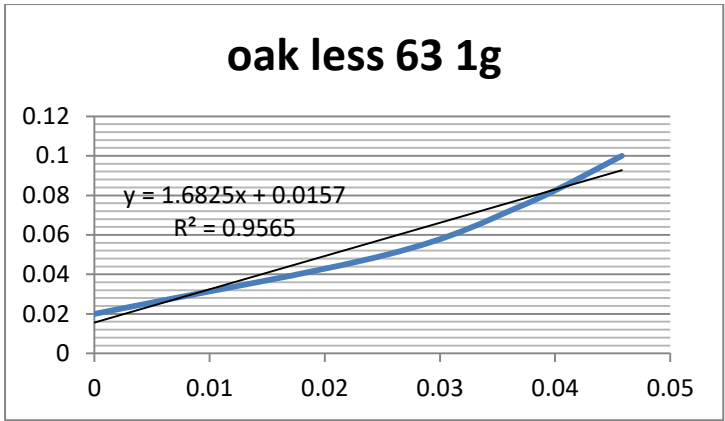
Oak 150 - 63 μm ($\text{Ø}=1=218.9$) 1 g, 750g/m³, $\text{Ø}=3.44$



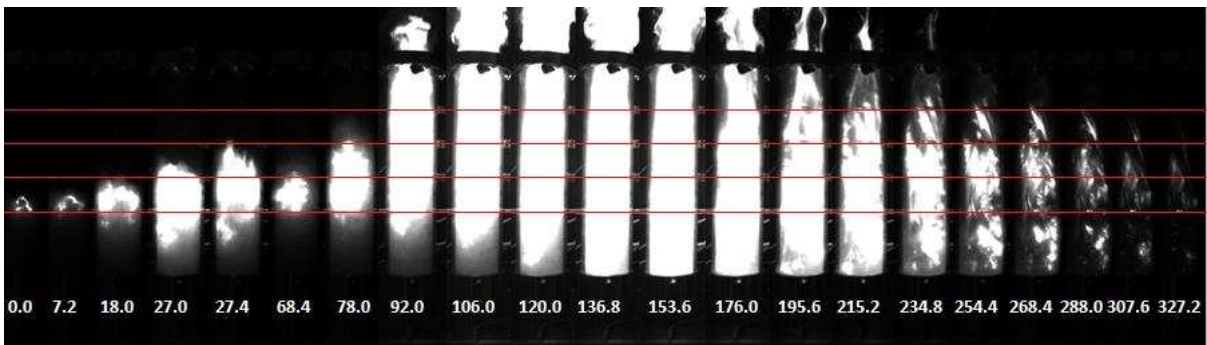
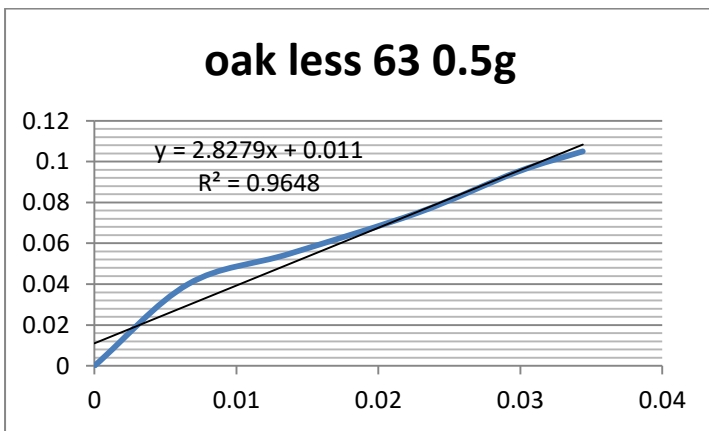
OAK less 63



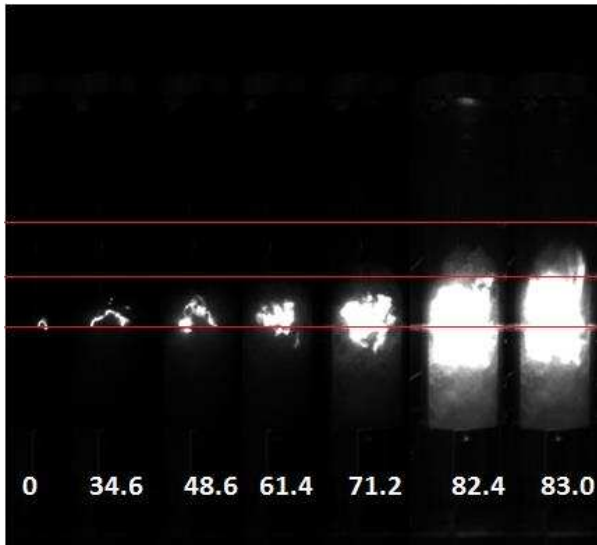
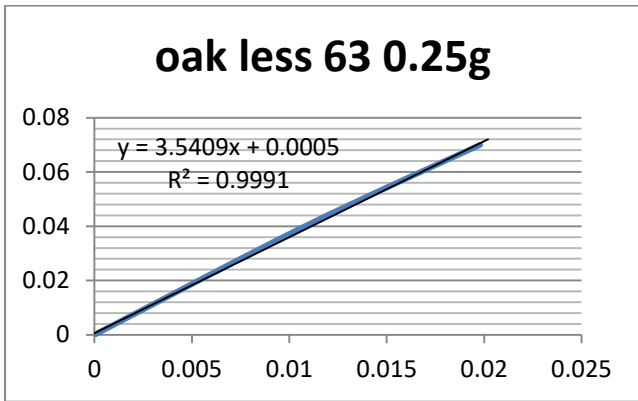
Oak less than 63 μm ($\text{Ø}=1=218.9$) 1 g, 750g/m³, $\text{Ø}=3.44$



Oak less than 63 μ m ($\emptyset=1= 218.9$) 0.5 g, 375g/m³, $\emptyset=1.71$



Oak less than 63 μ m ($\emptyset=1= 218.9$) 0.25 g, 187.5g/m³, $\emptyset=.86$



Oak less than 63 μ m ($\emptyset=1= 218.9$) 0.08 g, 60g/m³, $\emptyset=0.275$

