UNIVERSITY OF BIRMINGHAM

An Innovative Biofuel Approach – 2,5-Dimethylfuran (DMF)

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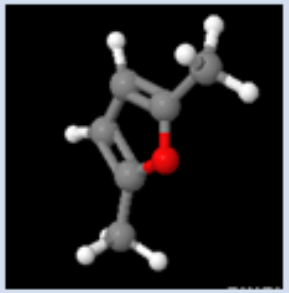
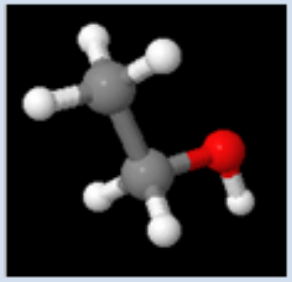
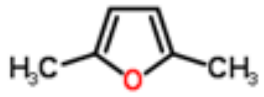
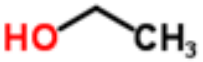
Presentation outline

- Background and objectives
- Experimental Systems
- Results and discussion
- Conclusions

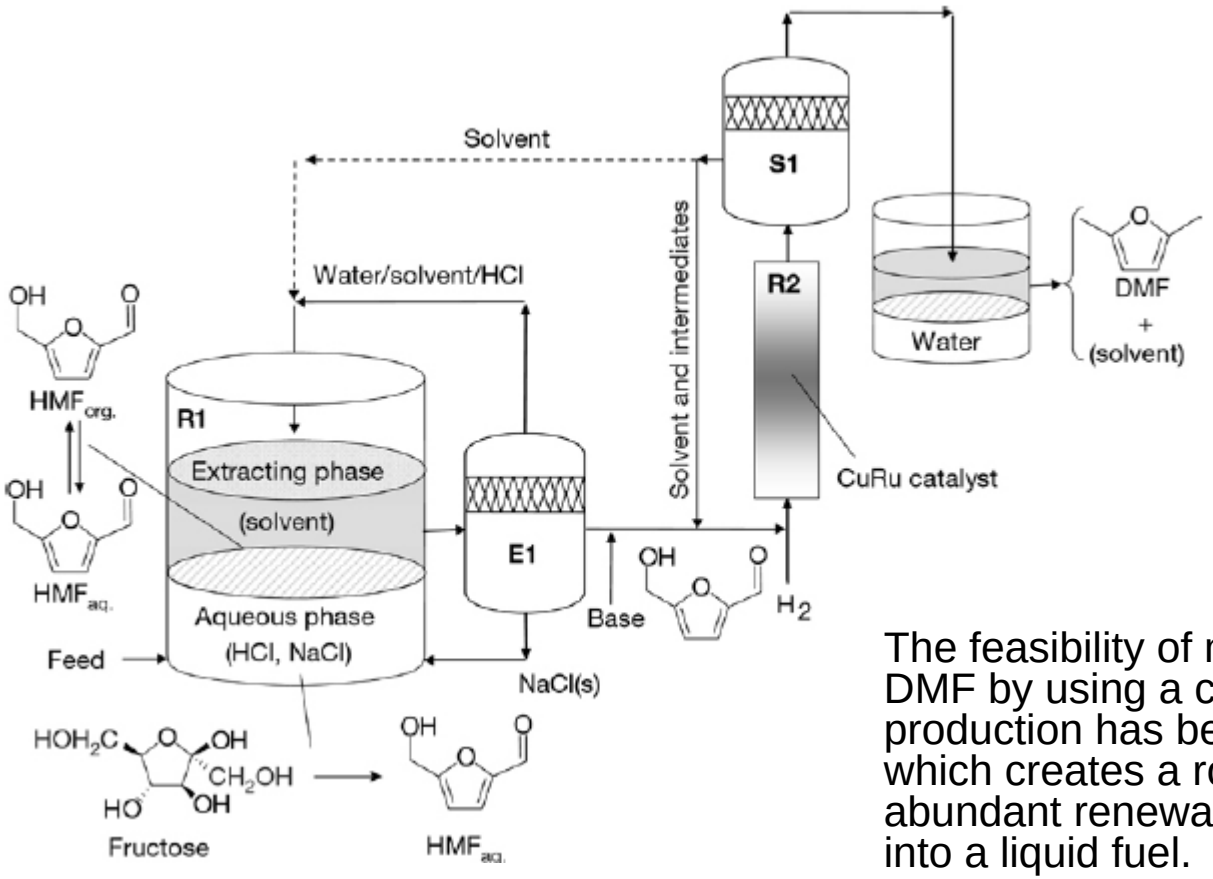
Acknowledgement

- The experiment work was carried out by Research Fellow Dr S Zhong, with setup of experimental engine systems from Dale Turner and Rob Stevens

What is DMF

Name(s)[i,ii]	2,5 Dimethylfuran	Ethanol	Gasoline
Linear Structure Formula[i]	$(CH_3)_2C_4H_2O$	CH_3OCH_3	Variable
Molecular Formula[i]	C_6H_8O	C_2H_6O	C_2 to C_{14}
Molecule 3D View[iv]			Variable
Molecule Schematic[iv]			Variable
BP, Boiling Point (1atm)[i]	93.0°C	77.3°C	
Enthalpy of Vaporization[iv] (20°C)	31.91$kJmol^{-1}$	43.2496$kJmol^{-1}$	
Enthalpy of Combustion[iii]	42.0$kJmol^{-1}$	26.9$kJmol^{-1}$	43.4$kJmol^{-1}$
ρ, Density of Liquid [i]	0.8954kgm^{-3} @20°C	0.79363kgm^{-3} @15°C	
Research Octane Number (RON)[v]	119	110[vii]	95[iv]
Auto Ignition Temperature[vii]	285.85°C	423°C	257°C

Breakthrough - new process of making DMF



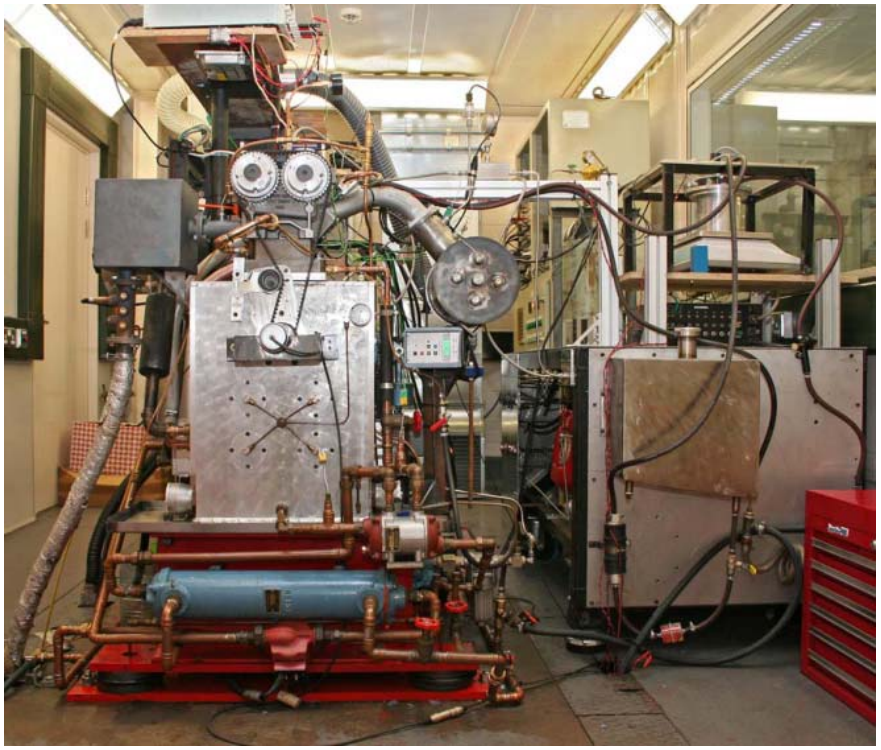
The feasibility of mass production of DMF by using a catalytic strategy in its production has been demonstrated, which creates a route for transforming abundant renewable biomass resources into a liquid fuel.

Nature 447 (7147): 982. doi:10.1038/nature05923, 2007

Why DMF is good?

- DMF has physical properties very close to gasoline, but it has a very high octane number (RON=119) and relatively low volatility.
- Compared to ethanol, it has an energy density higher by 50 per cent in volume and by 40% in mass.
- DMF is stable in storage and not soluble in water and therefore it cannot become contaminated by absorbing water from the atmosphere.
- It consumes only one-third of the energy in the evaporation stage of its production, compared with that required to evaporate a solution of ethanol produced by fermentation for biofuel applications.
- The most attractive advantage is that making DMF will not compete with land and food, and therefore it can be an ideal candidate for a new generation of sustainable bio-fuel!

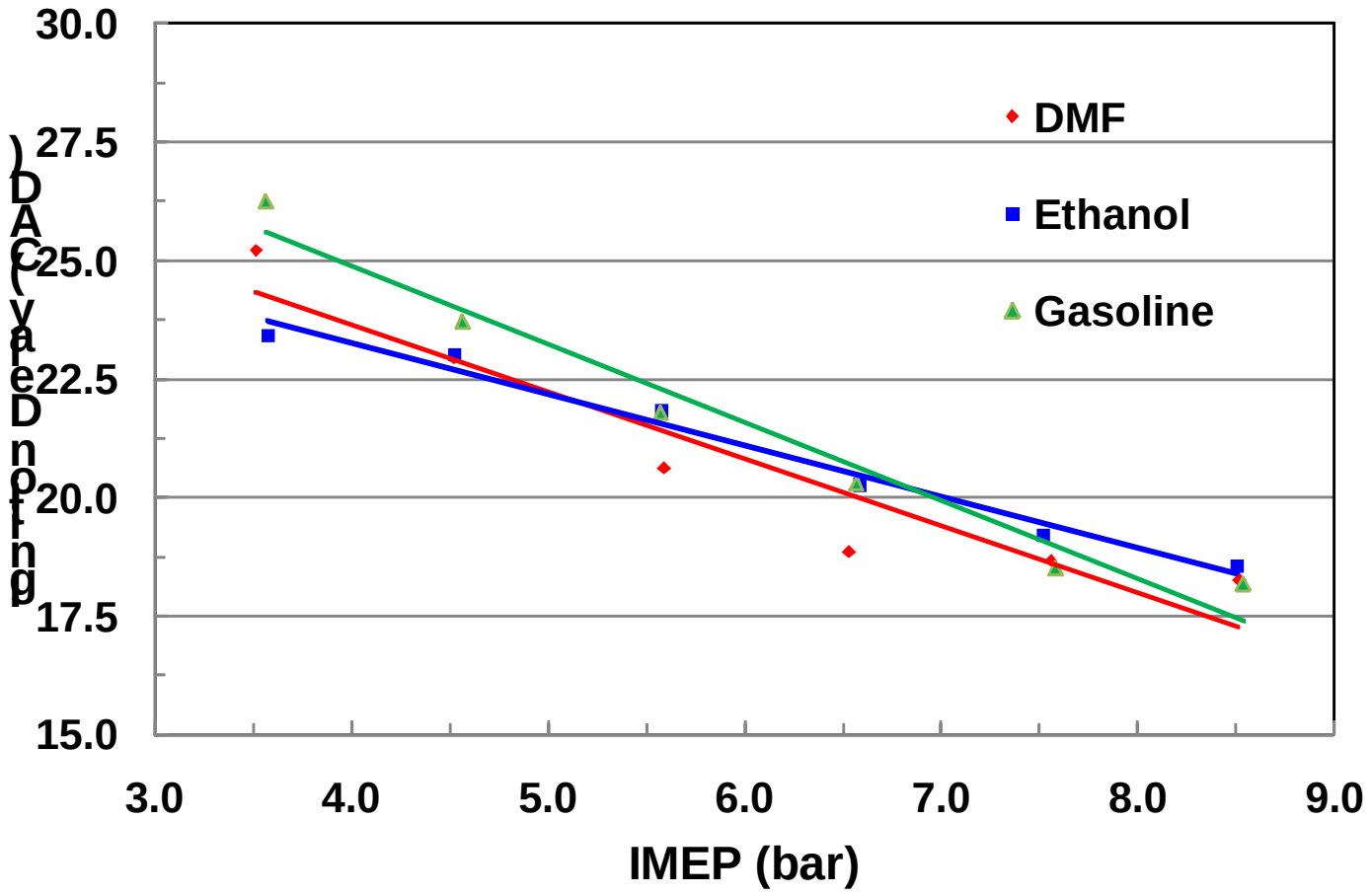
Single cylinder thermal engine



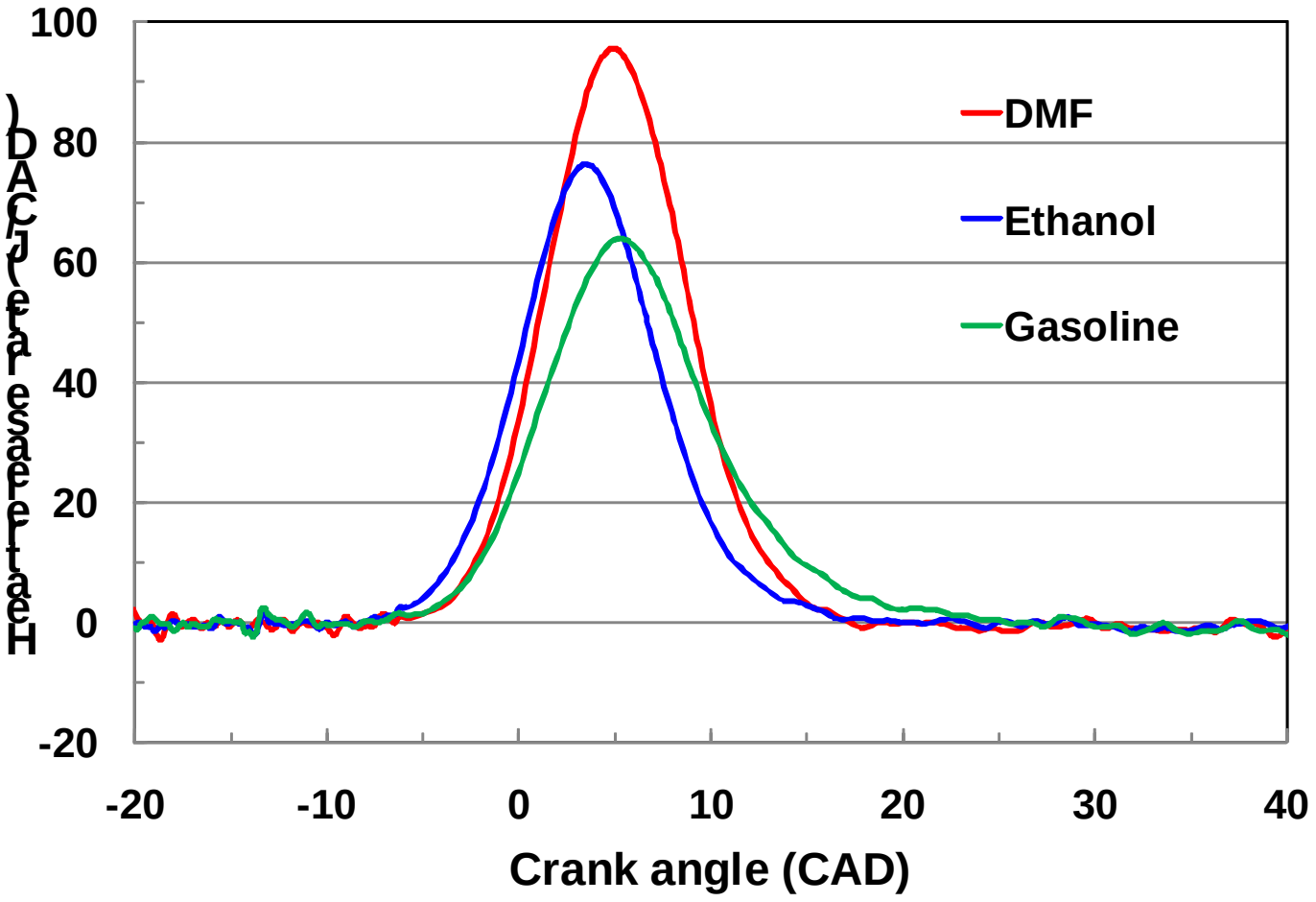
Bore x Stroke (mm)	90.0 x 88.9	
Swept. Volume (cm^3)	565.6	
Compression Ratio (Geometric)	11.5:1	
Fuel Delivery	Direct Injection	
Valves	**Intake**	**Exhaust**
Lift (mm)	2.65	2.10
Duration (CAD)	130	110

- **GDI (SG)**
- **Dual VCT**
- **Intake air heating 25- 250oC**
- **Fuels - PRF40 and PRF80**

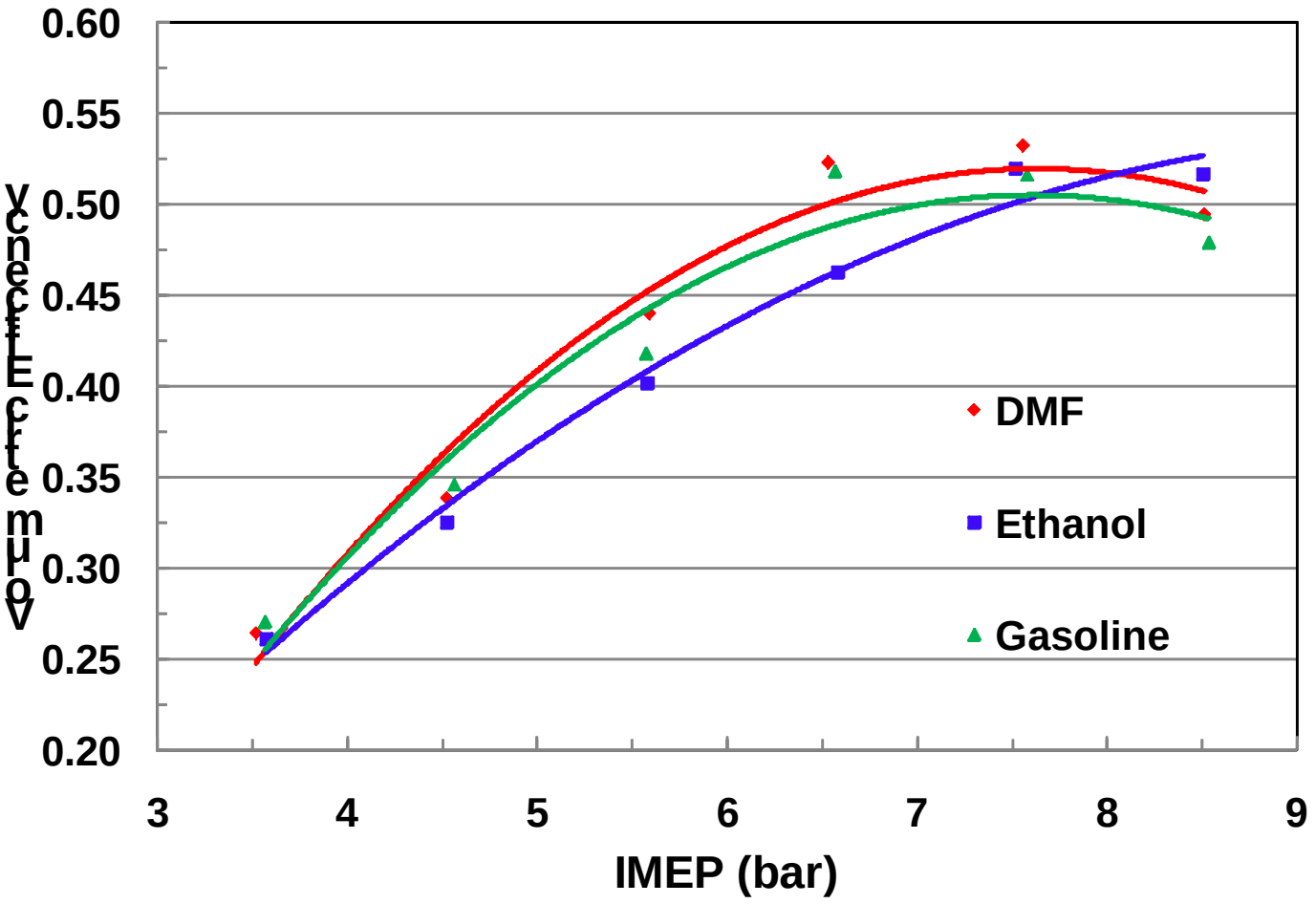
Ignition delay



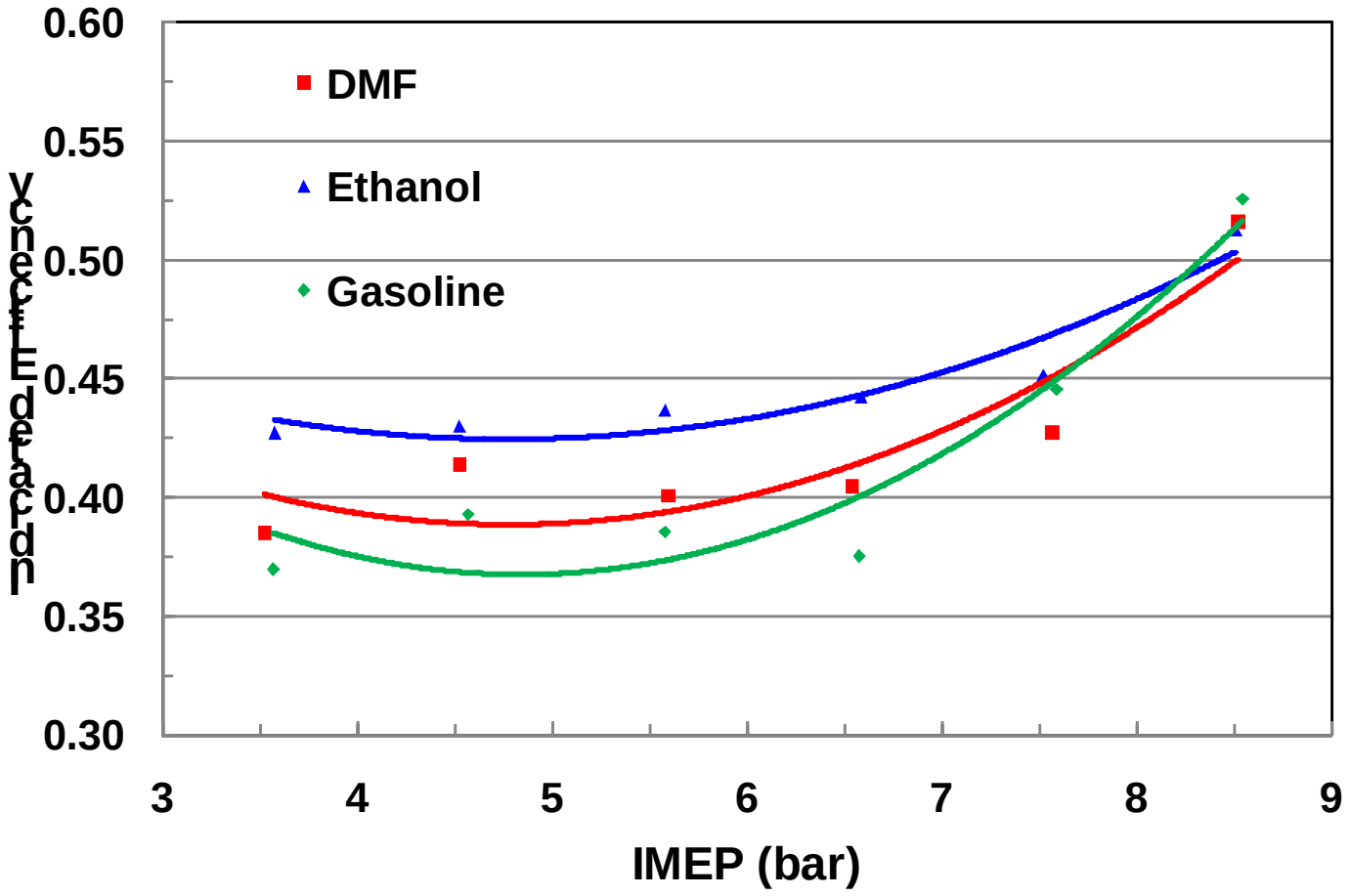
Heat release rate



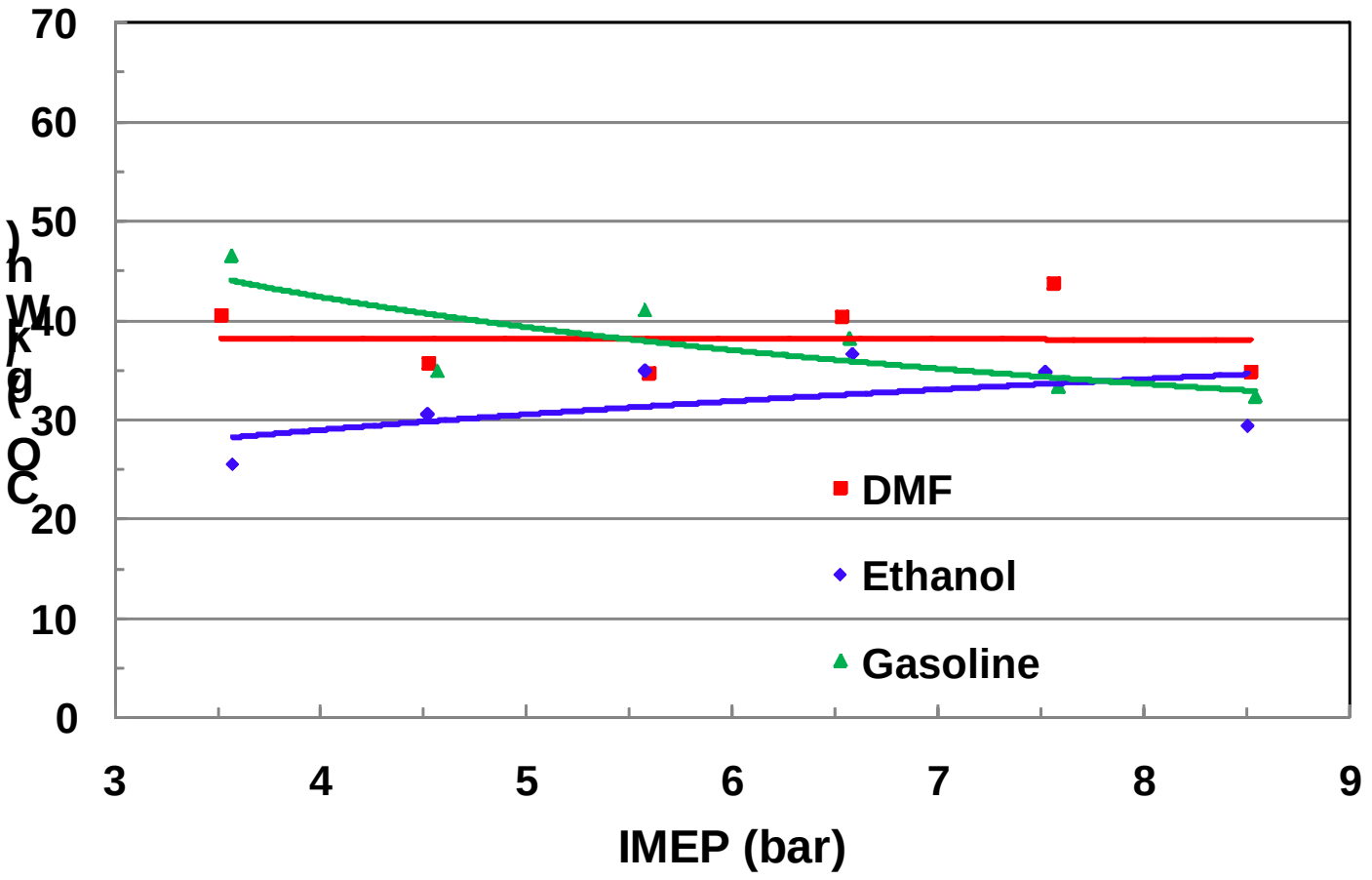
Volumetric efficiency



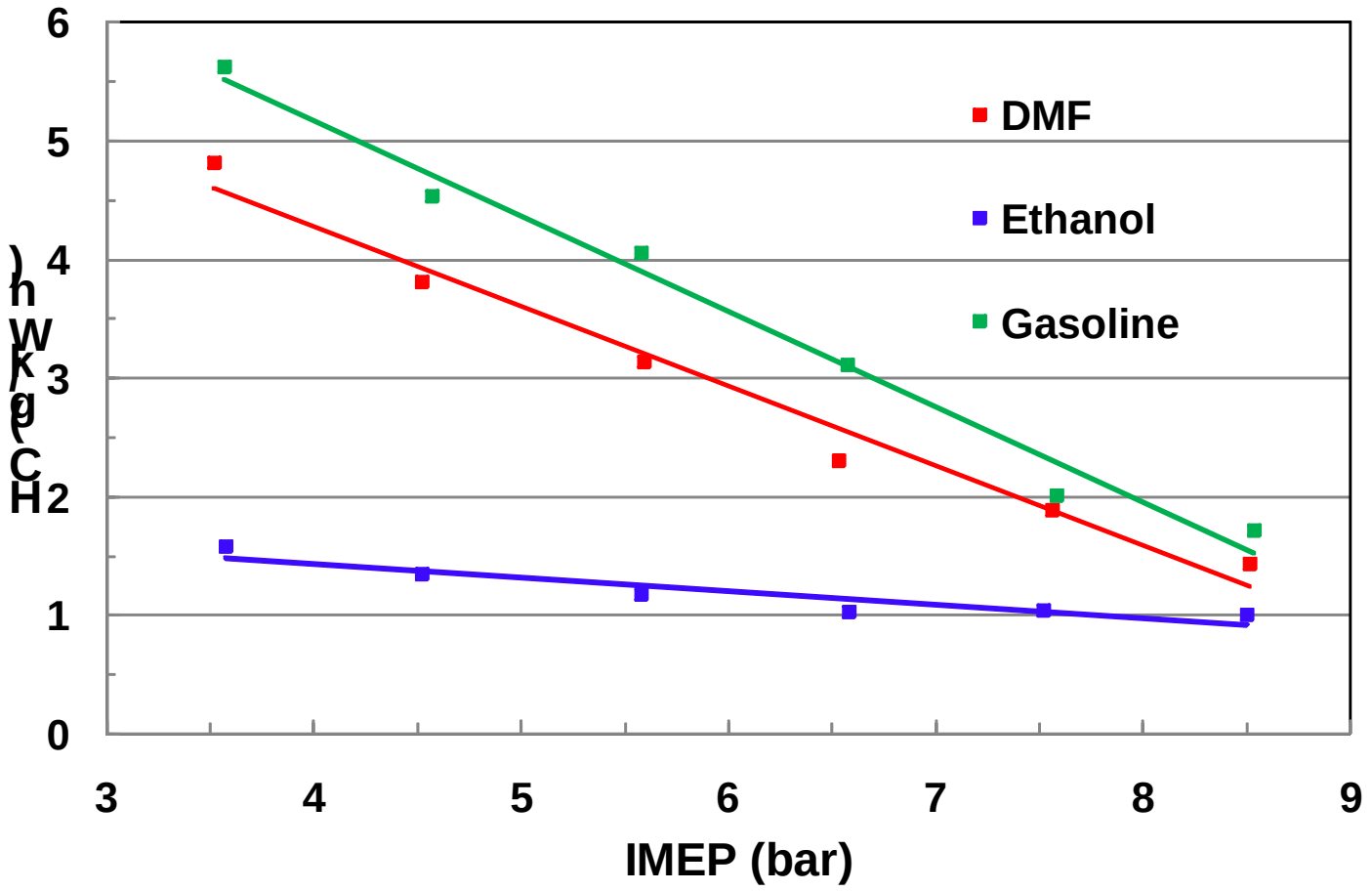
Engine efficiency



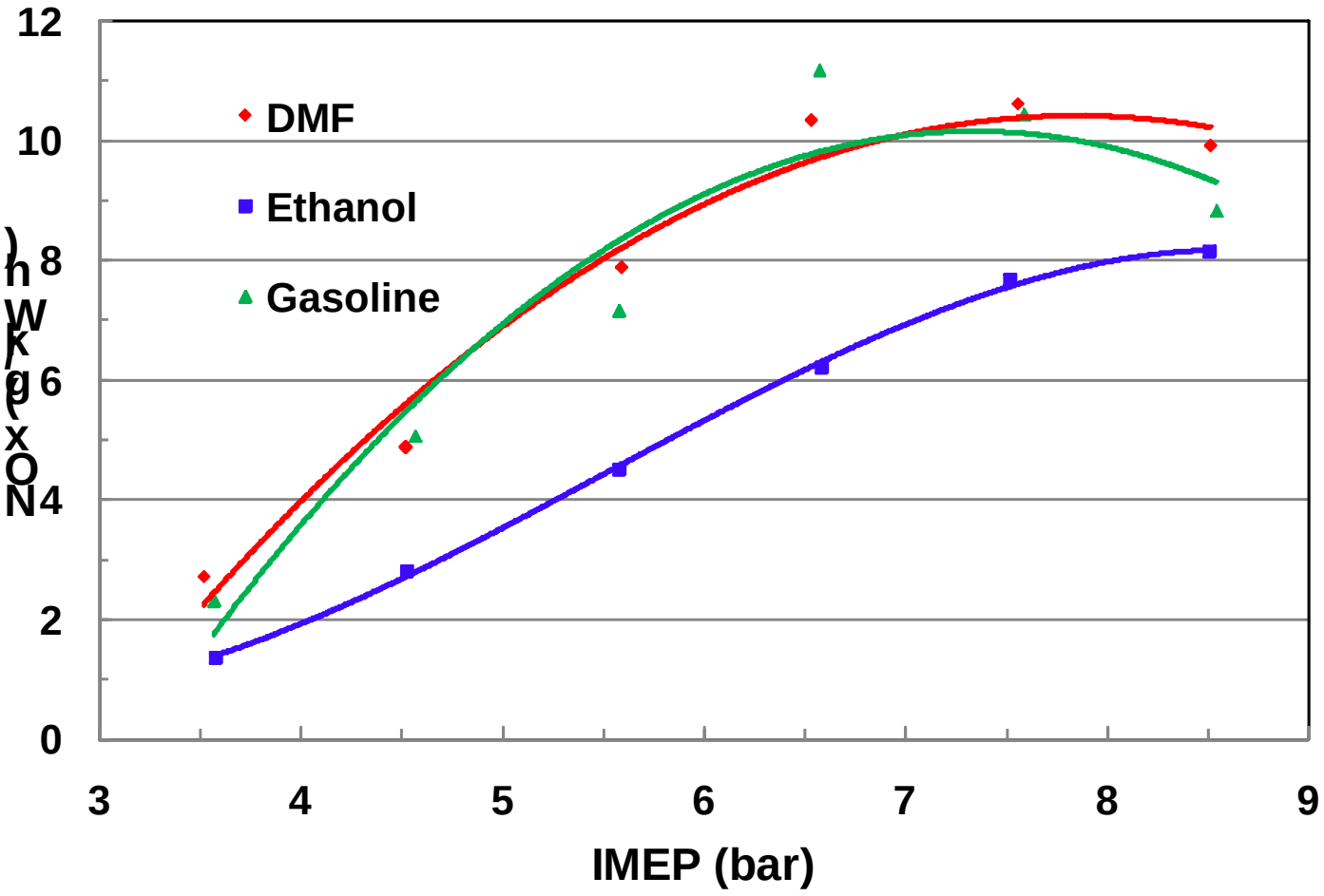
CO emissions



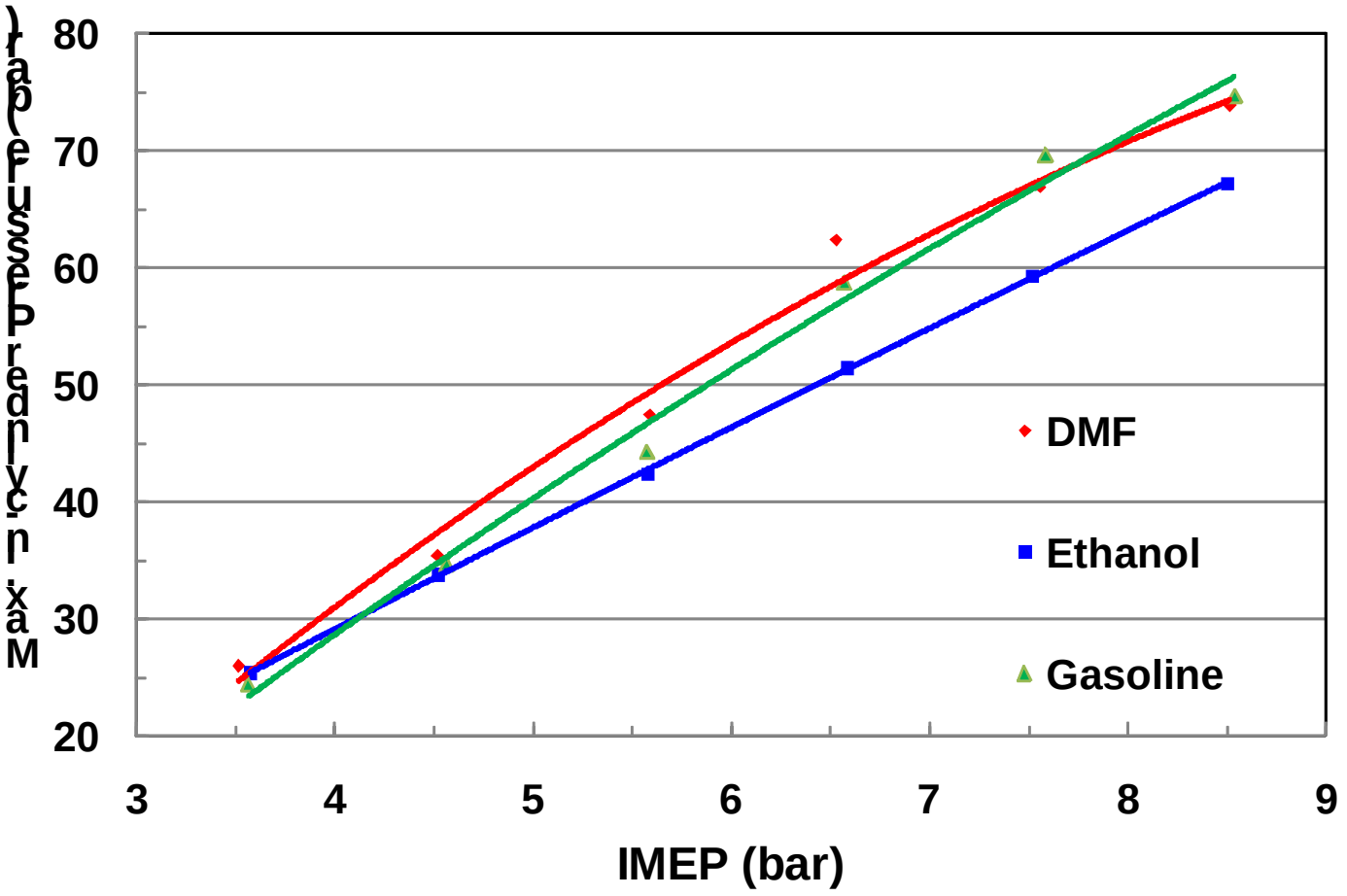
HC emissions



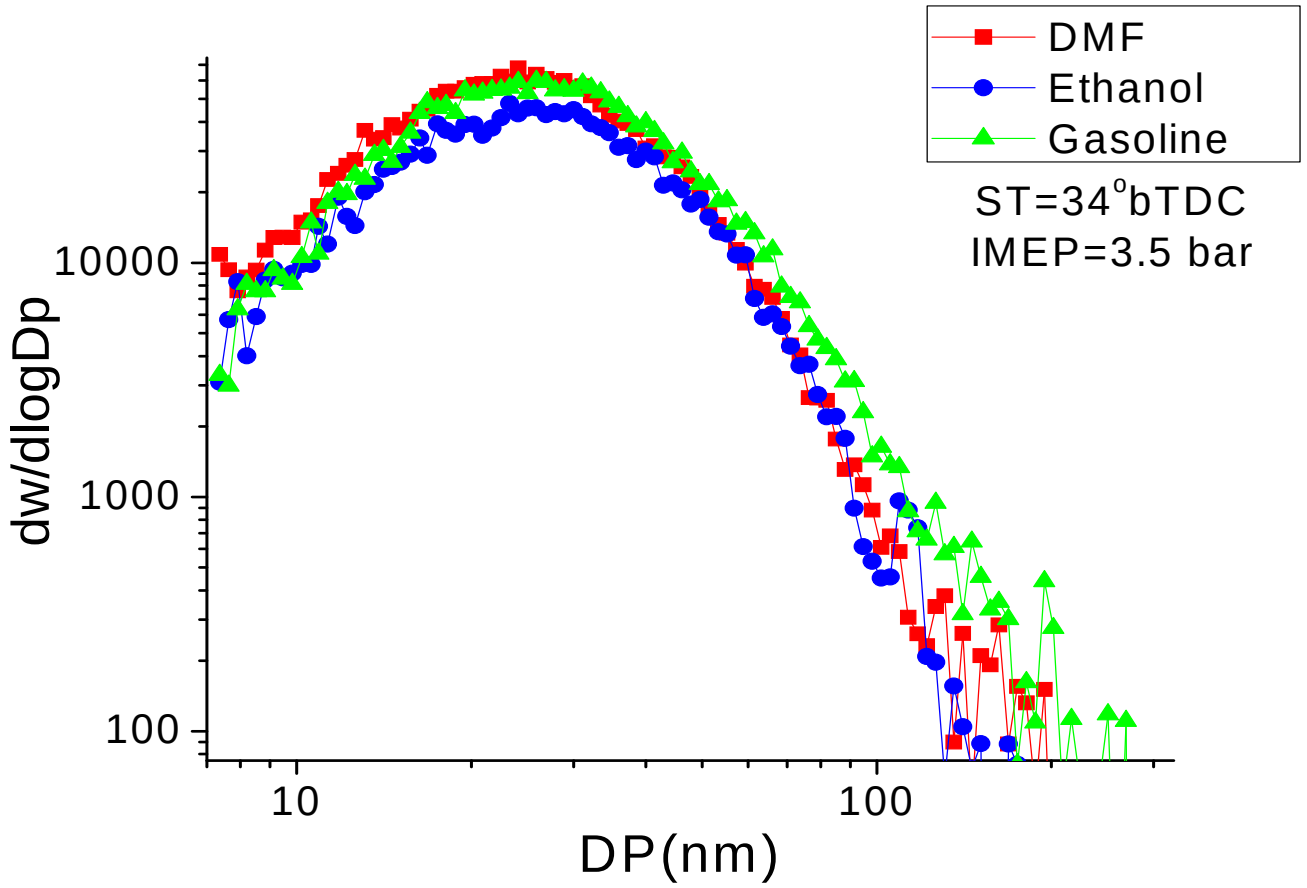
NOx emissions



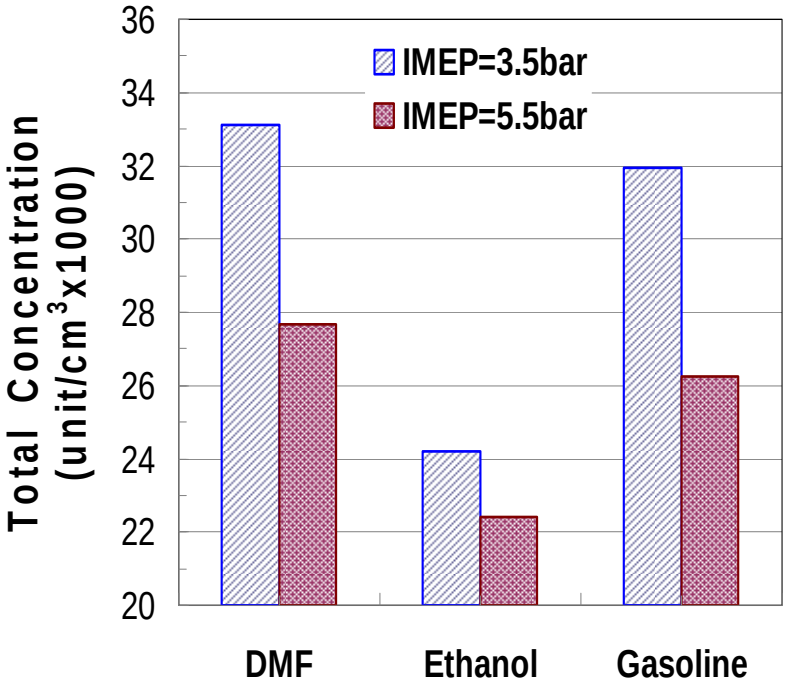
Maximum combustion pressure

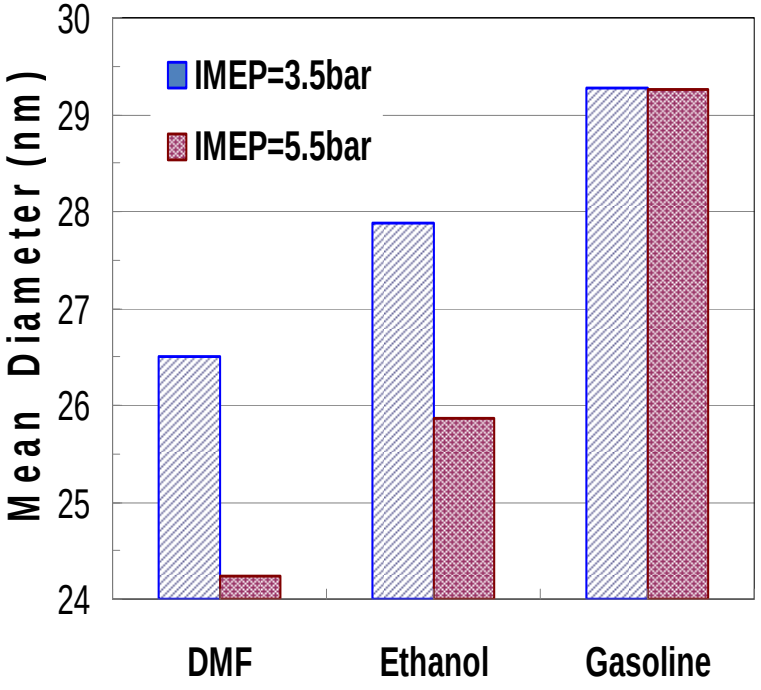


PM emissions



PM mass and numbers





Conclusions

- The ignition delay of DMF is shown to be shorter than that of gasoline. When it is compared with ethanol, the difference varies with load so that it is longer at the low load but shorter at higher load conditions.
- The emissions of CO, HC and NOx using DMF are all similar to those with gasoline.
- DMF's PM emissions are similar to that of gasoline. DMF actually produced the smallest count-mean sized particles of the three fuels which mean the total mass of PM for DMF can be estimated as the smallest.
- Overall, the experiments confirm that due to the physicochemical properties of DMF being similar to gasoline, DMF and gasoline exhibit very similar combustion and emissions characteristics.