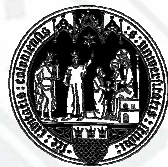


# WATER – BIOFUEL MICROEMULSIONS



UNIVERSITÄT  
ZU KÖLN

Pascal Wulff, Lada Bemert, Sandra Engelskirchen, Reinhard Strey

Institut für Physikalische Chemie, Universität zu Köln, Luxemburger Str. 116, 50939 Cologne, Germany.

pascal.wulff@uni-koeln.de

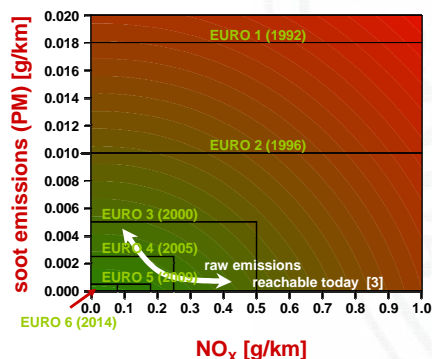
## Abstract

Fossil resources are limited. As alternative biogenic and sustainable fuels biodiesel (FAME, fatty acid methyl ester) and rape oil are available. Due to the physico-chemical properties of rape oil, such as the significantly high kinematic viscosity compared to diesel, an engine application proves to be difficult. Both fuel types generate emissions such as soot and nitrogen oxides ( $\text{NO}_x$ ) during combustion. However, microemulsification of these fuels with water allows a drastic reduction of

raw emissions in diesel engines [1]. Remarkably the soot - nitrogen oxide - trade of (diesel dilemma) is broken. Engine tests of biogenic fuels showed a soot reduction of about 80%, while nitrogen oxide emissions were reduced simultaneously by about 30%, analog to previous water diesel microemulsions. Additionally the microemulsification of rape oil leads to a lower viscosity, improving applicability.

## Challenge I

reaching European emission standards for diesel vehicles [2]



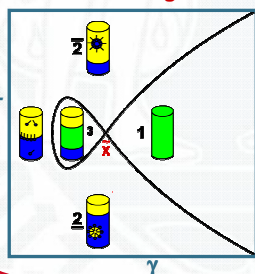
## our solution:

**Microemulsions**  
thermodynamically stable,  
macroscopically isotropic, nano structured [4]

(A) — (B) — (C)

hydrophilic — hydrophobic — amphiphilic

water/  
anti freeze      diesel fuel  
vegetable oil      biodiesel  
vegetable oil      vegetable oil      biogenic  
surfactant



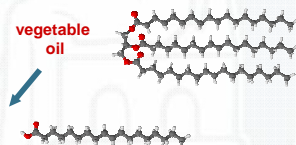
$$\alpha = \frac{m_{oil}}{m_{water} + m_{oil}}$$

$$\gamma = \frac{m_{surfactant}}{m_{overall}}$$

$$\alpha = 0.50$$

## Challenge II

being sustainable by using biogenic compounds



biodiesel / FAME  
(fatty acid methyl ester)

non ionic  
surfactants

ionic  
surfactants

demand as sustainable fuel additive

proposed as functional and sustainable fuel additives solubilizing water

## effect of water on soot

high combustion temperature  
splits water into radicals

oxygen radicals accelerate the  
degradation of fuel molecules

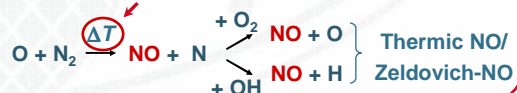


## How does water enhance the combustion process?

## effect of water on $\text{NO}_x$

excess heat vaporizes water  
 $\Rightarrow$  lower combustion temperature

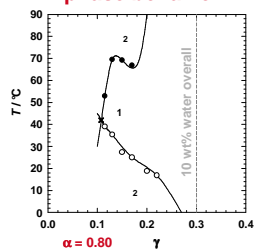
less thermal energy for this initial step available



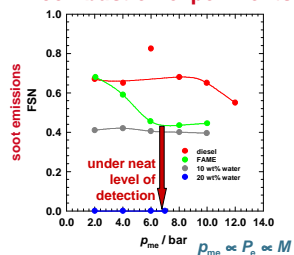
## FAME

water/anti freeze – FAME  
– non ionic/ionic surfactants

phase behavior

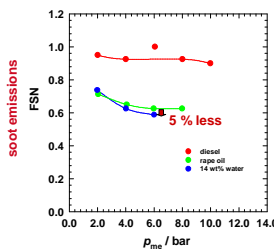
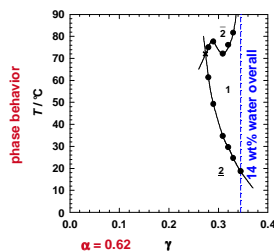


combustion experiments



## Rape oil

water/anti freeze – rape oil  
– non ionic/ionic surfactants



## Conclusion

$\Rightarrow$  microemulsions are suitable for biogenic fuels

- reduction of soot and  $\text{NO}_x$  emissions at the same time
- breaking the trade off
- performing at higher efficiency
- without increase of fuel consumption

$\Rightarrow$  sustainability of conventional fuels can be increased

- by using biogenic surfactants and biogenic antifreeze

$\Rightarrow$  fully biogenic microemulsions can be realized

- for FAME and rape oil

## Acknowledgement

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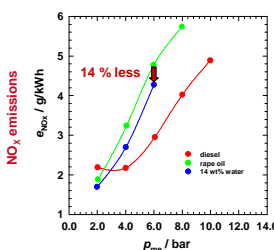
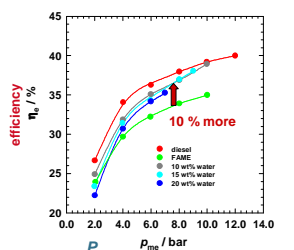
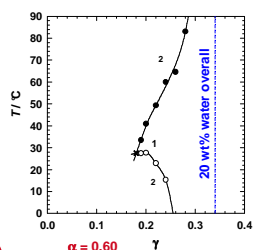
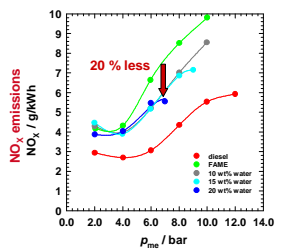
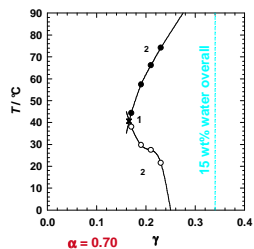


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$$\eta_e = \frac{P_e}{\dot{m}_f \cdot H_u}$$