BioEcoUVa

Universidad de Valladolid

TermoCal

Universidad de Valladolid

Metrología para la descarbonización de la red de gas

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congreso español de metrología m 22

GOBIERNO DE ESPAÑA
MINISTERIO DE INDUSTRIA, COMERCIO Y TURISMO

CEM CENTRO ESPAÑOL DE METROLOGÍA

Ávila, del 27 al 29 de septiembre de 2022

Outline

- **TermoCal**
- Motivation
- Low-carbon gas networks
  - Decarb
  - Accurate Thermophysics
- Discussion

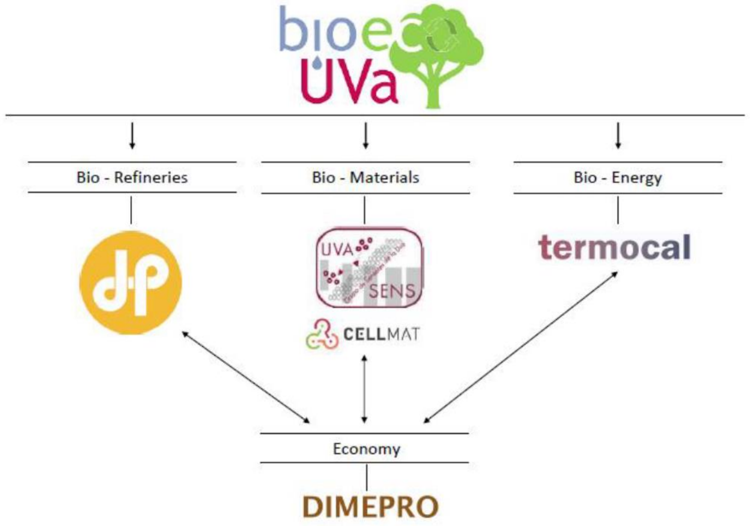



TermoCal
University of Valladolid
Thermophysics & Calibration




TermoCal
University of Valladolid
Thermophysics & Calibration

1) **Fundamental Metrology**
2) **Thermophysical Properties and Phase Behaviour** of multicomponent fluid mixtures over wide ranges of temperatures, pressures and chemical compositions
3) **Exergy analysis** of systems and processes



Technique	Property	Temperatures	Maximum Pressure	Uncertainty*
Single-sinker Magnetic Suspension Densimeter	Gas Density	(250 to 400) K	20 MPa	(0.02 to 0.4) %
Spherical Acoustic Resonator	Speed of Sound in Gases	(200 to 475) K	20 MPa	0.02 %
Flow Calorimeter	Isobaric Heat Capacity	(240 to 420) K	25 MPa	0.4 %
Vibrating Tube Densimeter	Density	(240 to 420) K	140 MPa	0.1 %
Flow Calorimeter	Excess Enthalpy	(240 to 420) K	25 MPa	1.0 %
Falling Body Viscometer	Viscosity	(240 to 475) K	140 MPa	3 %
Vibrating Wire Viscometer	Viscosity	(200 to 475) K	140 MPa	1.5 %
Static Isochoric Total Pressure VLE Cell (Van Ness)	Phase Equilibrium	(240 to 400) K	10 MPa	0.001 in liquid mole fraction
Cylindrical Microwave Resonator	Phase Equilibrium	(200 to 360) K	50 MPa	0.1 % in pressure

* Overall Expanded Uncertainty (k =2)

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EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Junta de Castilla y León

CEM CENTRO ESPAÑOL DE METROLOGÍA
Imperial College London
INTA
SCCS
BAM Bundesanstalt für Materialforschung und -prüfung
enagas

NIST
INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA
NPL National Physical Laboratory
CTP ParisTech
universidade de aveiro
CARBUROS METALICOS Grupo Air Products
COSTAIN
energy technologies institute

ACLNGF Australian Centre for LNG Futures
1495 UNIVERSITY OF ABERDEEN
Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa
Curtin University
RUHR UNIVERSITÄT BOCHUM RUB
PTB

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA
UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR
HERIOT WATT UNIVERSITY
IMP INSTITUTO MEXICANO DEL PETRÓLEO
UniversidadeVigo
UCA UNIVERSITÉ Clermont Auvergne

IBERDROLA

Competitive EU Projects

MefHySto
Metrology for Advanced Hydrogen Storage Solutions

PROMETH2O

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Metrology for decarbonising the gas grid

MetCCUS

- TermoCal
- **Motivation**
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Natural gas is currently the primary source of energy for heat in Europe and to meet climate change targets we need to quickly introduce **biomethane**, **hydrogen enriched natural gas**, **100% hydrogen**, and **CCS technologies**.

EMPIR EURAMET

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Metrology for decarbonising the gas grid

- TermoCal
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    - **Decarb**
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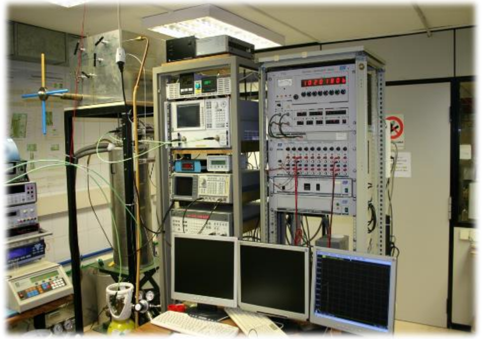
Spherical Acoustic Resonator



(200 to 475) K

20 MPa

$U(T)$ (k = 2) = $2.0\cdot10^{-3}$ K

(0 −3) MPa: $U(p)$/MPa (k = 2) = $60\cdot10^{-6}\cdot p$/MPa + $0.6\cdot10^{-3}$

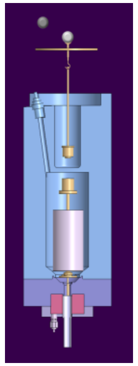
(3 − 20) MPa: $U(p)$/MPa (k = 2) = $60\cdot10^{-6}\cdot p$/MPa + $1.0\cdot10^{-3}$

U_r(w) (k = 2) = $2.2\cdot10^{-4}\cdot$ m·s^{-1} / m·s^{-1} $U_r(c_p)$ (k = 2) = $1\cdot10^{-3}$

Single Sinker Magnetic Suspension Densimeter

(250 to 400) K

20 MPa



$U(T)$ (k = 2) = $4.0\cdot10^{-3}$ K

(0 −3) MPa: $U(p)$/MPa (k = 2) = $60\cdot10^{-6}\cdot p$/MPa + $1.7\cdot10^{-3}$

(3 − 20) MPa: $U(p)$/MPa (k = 2) = $75\cdot10^{-6}\cdot p$/MPa + $3.5\cdot10^{-3}$

$U(\rho)$/kg·m^{-3} (k = 2) = $1.1\cdot10^{-4}\cdot\rho$/kg·m^{-3} + $2.3\cdot10^{-2}$

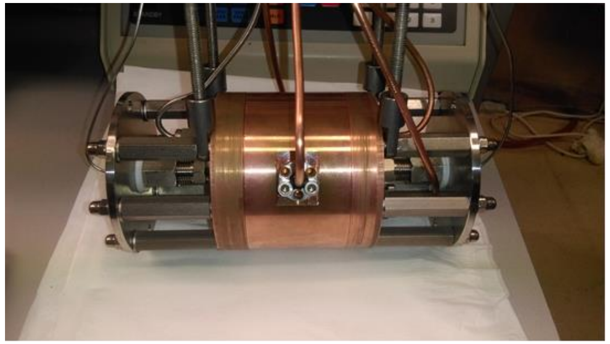
WP3. 3.1.1; 3.1.3; 3.1.4 (ρ and w of H_2 and alkane binary mixtures)

$250 < T/K < 330$ $p < 12$ MPa

$H_2 + C_3H_8$ and $H_2 + C_4H_{10}$ (25, 50, 75)%

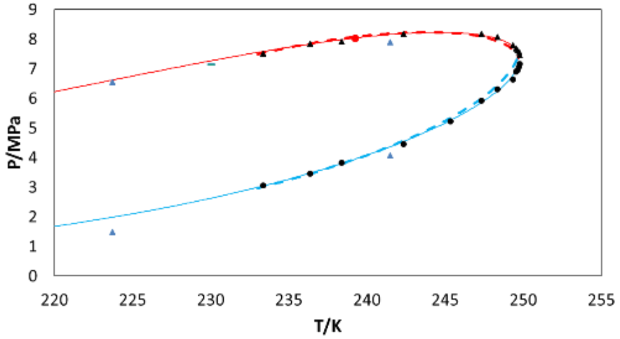
$U_r(w) = 0.02$ % $U_r(\rho) = 0.05$ %

MW Cavities (TU-CH, UVa)



(230 to 340) K

10 MPa



$U(T)$ $(k = 2) = 20 \cdot 10^{-3}$ K

(0 −3) MPa: $U(p)$/MPa $(k = 2) = 200 \cdot 10^{-6} \cdot p$/MPa $+ 6 \cdot 10^{-3}$

(3 − 20) MPa: $U(p)$/MPa $(k = 2) = 200 \cdot 10^{-6} \cdot p$/MPa $+ 10 \cdot 10^{-3}$

$0.0010 < U(x)$ $(k = 2)$ mol·mol^{-1} < 0.010

WP3. Task 3.2

VLE Vapour liquid equilibrium of hydrogen and alkane binary mixtures

$H_2 + C_3H_8$ and $H_2 + C_4H_{10}$

H_2 Impurities (H_2O): Accurate Thermophysics. *f*

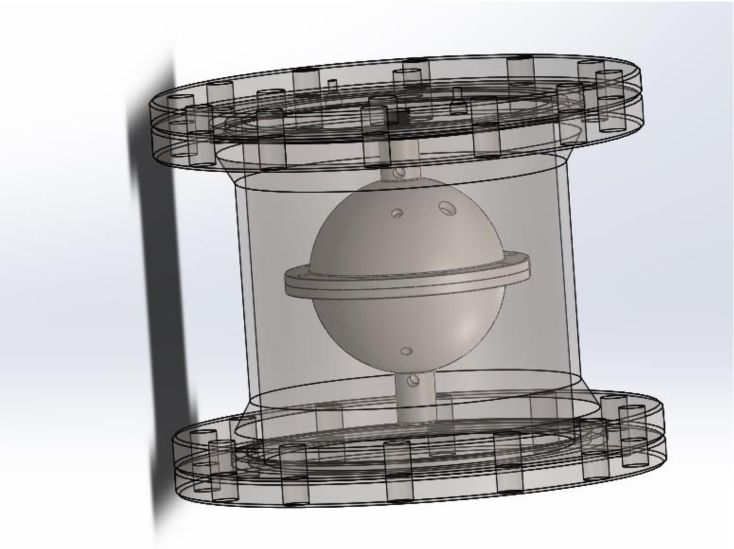
Quasi-Spherical MW Resonator

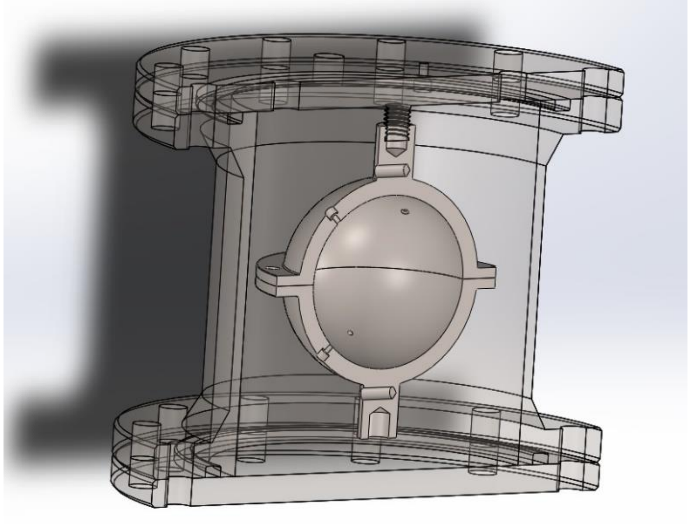
PROMETH2O

$200\ \mathrm{K} < T < 400\ \mathrm{K}$
$p < 3\ \mathrm{MPa}$

$U_r(p) = 0.015\%$
$U(T) = 4\ \mathrm{mK}$
$U_r(x_w) = 2\%$
$k = 2$

$D_x = 50.08\ \mathrm{mm}$
$D_y = 50.16\ \mathrm{mm}$
$D_z = 50\ \mathrm{mm}$





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Q & A

David Vega-Maza

28/09/2022

X_w, T_{DP}

$$x_w = \frac{\left(\frac{\varepsilon_{mix}-1}{\varepsilon_{mix}+2}\frac{\varepsilon_{dry}+2}{\varepsilon_{dry}-1}\right)-1}{\wp_w/\wp_{dry}-1}$$

$$\varepsilon_{mix}(p,T) = \varepsilon_{dry}(p,T)\left(\frac{f_{dry}(p,T)}{f_{mix}(p,T)}\right)^2$$

$$\wp_{mix}(p,T) = \frac{1}{\rho_{mix}}\frac{\varepsilon_{mix}-1}{\varepsilon_{mix}+2} \qquad \wp_{dry}(p,T) = \frac{1}{\rho_{dry}}\frac{\varepsilon_{dry}-1}{\varepsilon_{dry}+2} \qquad \wp_{mix} = \wp_w x_w + (1-x_w)\,\wp_{dry}$$