



With the contribution of the LIFE
programme of the European Union
LIFE21-ENV-FI-Project 101074439



GREENCASTING



Green Casting LIFE

(LIFE21-ENV-FI-101074439)

EMISSION MEASUREMENTS



EMISSION TEST OVERVIEW

Concept	Laboratory tests	Pilot-scale test	Industrial-scale
Sand molds (weight)	Tested sample/core 150 g	110 kg	500 kg (small molds) 1,500 kg (large molds)
Iron cast (weight)	8,500 g	60 kg	110 kg (for small molds) 380 kg (for large molds)
Metal/Ratio sand		1:2	1:5
Simple/combined Sand Sample and binder ref.	<p>Core (tested sample: 150 g)</p> <p>8 binding systems. 10 combinations</p> <p>7 inorganic binder based on sodium silicate or geopolymer. Different hardening systems (no bake, CO₂ and warm box):</p> <ol style="list-style-type: none"> 1) GEOPOL W (warm air) (GW) 2) GEOPOL CO₂ (GCO₂) 3) Cast Clean no bake (CK) 4) SOLOSIL warm box (STX) 5) CARSIL no bake (CV) 6) SOLOSIL CO₂ (SCO₂) 7) KOLDEX no-bake (KS) <p>One organic binder (PEP SET).</p> <ol style="list-style-type: none"> 8) PEP SET no-bake (PS) 9) Cast Clean no bake + protective coating (CK + coating) 10) PEP SET no-bake + protective coating (PS + coating) 	<p>Mold + core</p> <p>9 combinations</p> <p>Mold / Core:</p> <ol style="list-style-type: none"> 1) Organic: furan/furan (FA) 2) Inorganic: geopol/geopol (IG) 3) Inorganic: CastClean/CastClean (IP) 4) Combined: Green/PS (GMPU) 5) Combined Green/ geopol (GMIG) 6) Combined Green/ CastClean (GMIP) 7) Organic: Phenolic Urethane (PUNB) 8) Organic Alkaline Phenolic (APNB) 9) Combined: Alkaline Phenolic / Cast Clean (APIP) <p>All NO BAKE binder systems.</p>	<p>Mold + core</p> <p>7 combinations</p> <p>Mold / Core:</p> <ol style="list-style-type: none"> 1) Organic Pep Set / Pep Set 2) Inorganic Cast Clean / Inorganic Cast Clean / 3) Inorganic Geopol / Inorganic Geopol 4) Inorganic Cast Clean / Organic Pep Set 5) Inorganic Geopol / Organic Pep Set 6) Organic Pep Set / Inorganic Geopol 7) Organic Pep Set / Inorganic Cas Clean
Method	Patent no. PL 224705 B1, 2017. The sand sample is poured with liquid cast and gases are directed into the pump by means of a steel pipe via the heating system, drying system	<p>Chamber Test</p> <p>The mold is placed in a metal box with a flap opened in the upper part, through which liquid metal was poured into the mold. The box was equipped with a connector, through which gases generated in the process were sucked</p>	
T° liquid cast iron	1380-1420°C	1350-1390°C (OPSA: ductile iron: 1400 -1420 °C)	
Pollutants measurement	BTEX, PAHs, phenol, formaldehyde, CO, SO ₂ , NO _x and particulate matter PM		
Specific pollutants	Isocyanates optionally for Pep Set system, Tvoc, gas volume	Crystalline Silica	Crystalline Silica, Isocyanates optionally for combinations with Pep Set, TVOC
Test Location	AGH UNIVERSITY OF KRAKOW (Poland)	FUNDACION AZTERLAN (Spain)	OPSA foundry (Poland)



ODLEWNIENI POLSKIE S.A.



Pilot scale: 9 molds (100kg mould + 4 kg core) : 60kg of iron cast

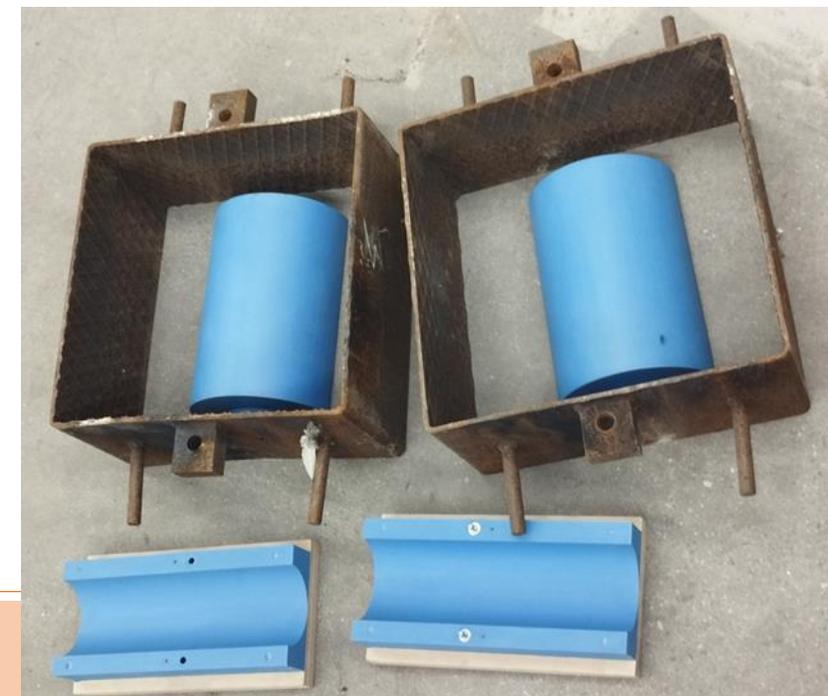
Moulds under two configurations:

- **homogeneous** systems: both mold and cores were manufactured using the same binder (5 trials),
- **heterogeneous** systems: different binders were used for mold and cores (4 trials).
 - **PUNB**—Mold and core with Phenolic Urethane No-Bake binder
 - **FA**—Furan (based on Furfuryl Alcohol)
 - **APNB**—Mold and core with Alkaline–Phenolic No-Bake
 - **IG**—Mold and core with inorganic geopolymer
 - **IP**—Mold and core with inorganic sodium silicate
 - **APIP**—Alkaline–Phenolic mold+ Inorganic silicate core
 - **GMPU**—Green mold (clay-bonded) + Phenolic Urethane No-Bake core
 - **GMGI**—Green mold (clay-bonded) + Inorganic geopolymer core
 - **GMIP**—Green mold (clay-bonded) + Inorganic sodium silicate core



System	Binder (%) Over Sand	Hardener (%) Over Binder
Phenolic Urethane No-Bake (PUNB)	1.2 (R1 + R2)	5 (over R1)
Furan (FU)	1	30
Alkaline-Phenolic No-Bake (APNB)	1.7	20
Geopolymer (IG)	2	16
Sodium silicate (IP)	2.5	10
Green (GM)	9% bentonite/3% coal dust/4% water	

Dosage of different binder according to the supplier



MOULDS / CORES

PUNB



FA



GMIP



AP



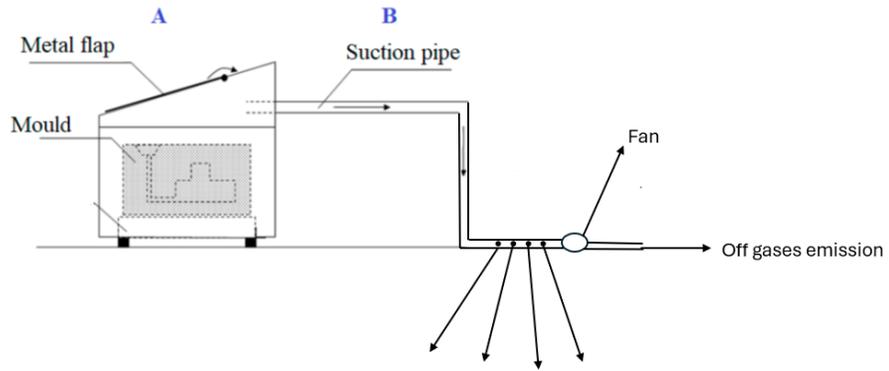
IG



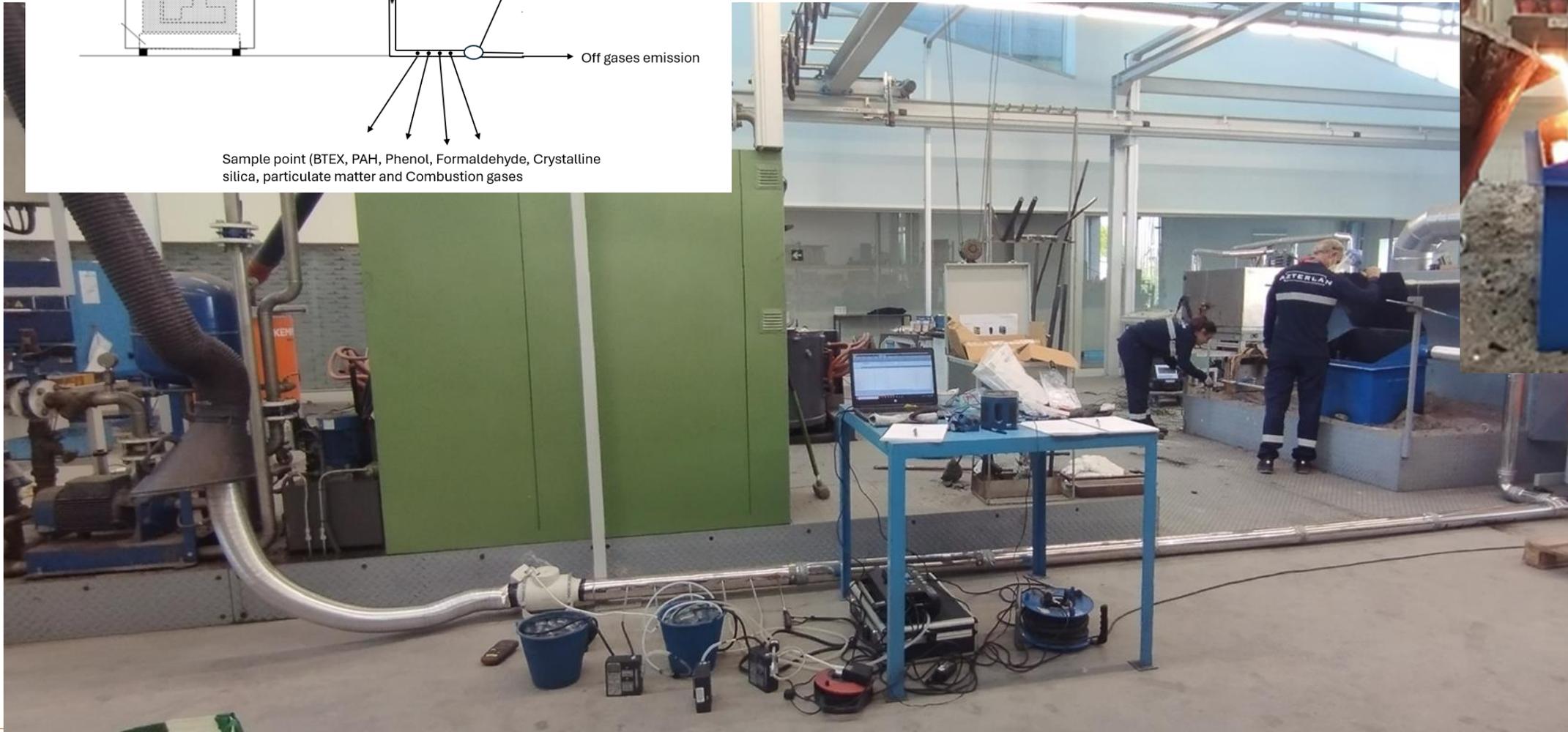
IP



TEST DESIGN



Sample point (BTEX, PAH, Phenol, Formaldehyde, Crystalline silica, particulate matter and Combustion gases)



EQUIPMENT



Mould and core making

- Pilot / industrial sand mixer



1. Temperature
2. Crystalline silica
3. BTEX
4. Formaldehyde
5. PAH
6. Combustion Gases



Gases

NO-NO₂, CO, SO₂, and total COV

Particulate Matter

PM₁₀, PM_{2,5}, PM₄ and PM₁.)

MEASUREMENT EQUIPMENT

5 Sampling Pumps (SKC type).

Determination of **individual VOCs** (Benzene, toluene, phenol, formaldehyde, furfuralic alcohol...etc), **PAH, particulate matter and crystalline silica**

**KUNAK**

Online measurements of gases **NO-NO₂, CO, SO₂**, and **total COV** and particulate matter (**PM10, PM2,5, PM4** and **PM1.**)

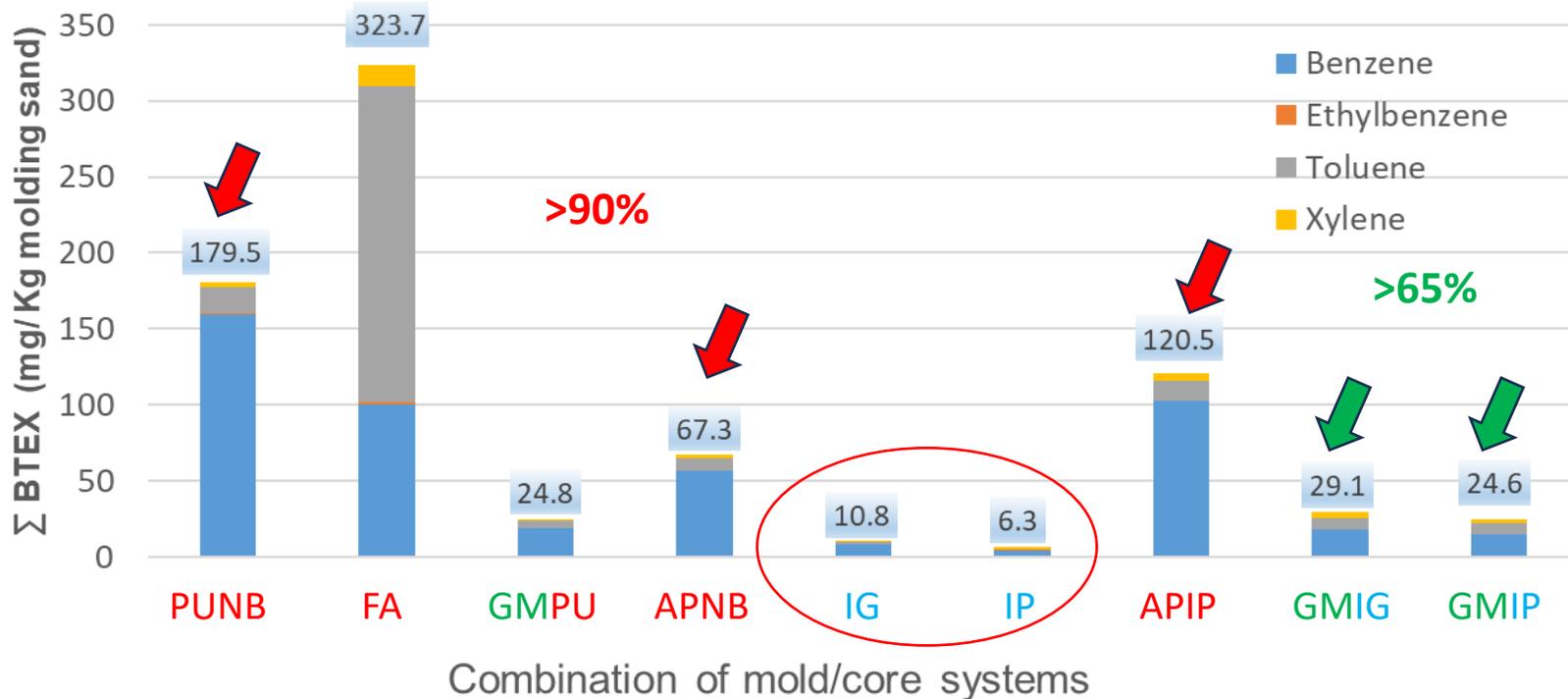
**TESTO 350 Combustion Gas Analyzer**

Real-Time measures of exhaust gases. (CO, O₂, NO_x, and SO₂)



Benzene, toluene, ethylbenzene, and xylene emissions

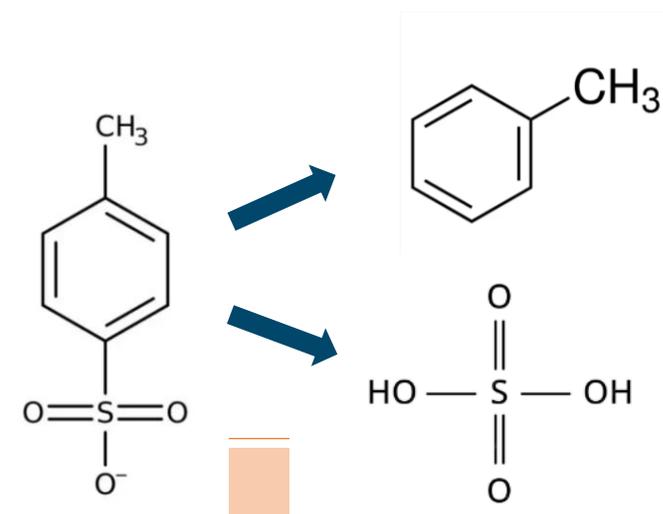
BTEX concentration by system



Legend

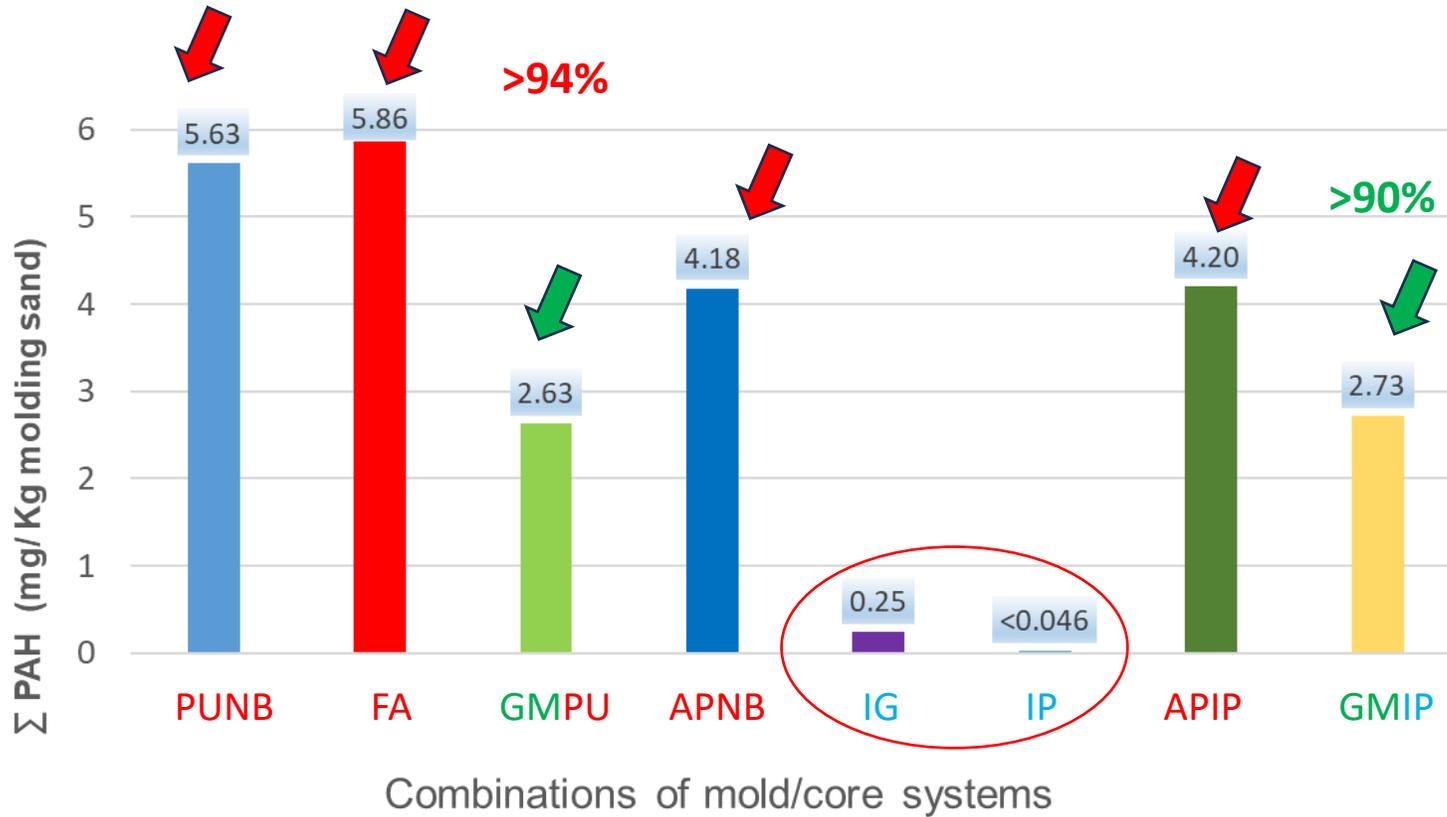
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Furan system → Higher Toluene emission → Toluene base hardener



Polycyclic Aromatic Hydrocarbons emissions

PAH concentration by system

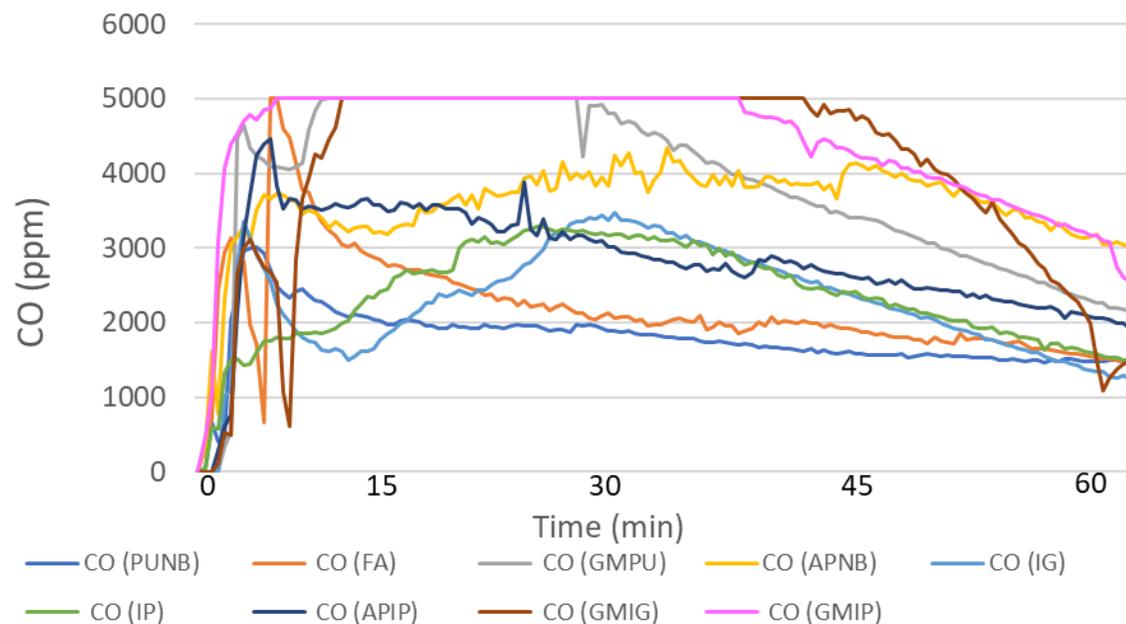
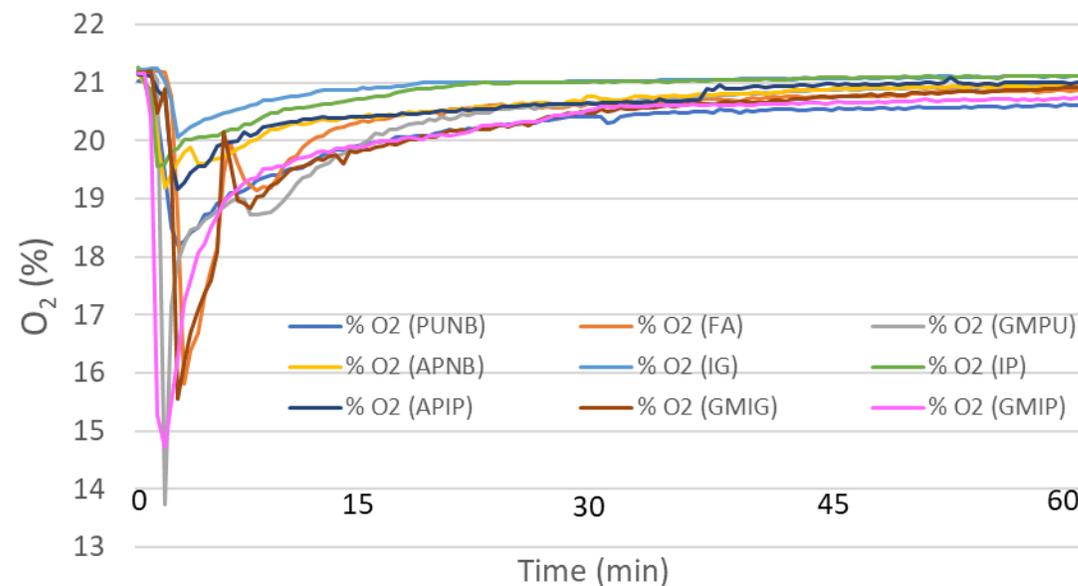


Individual PAH

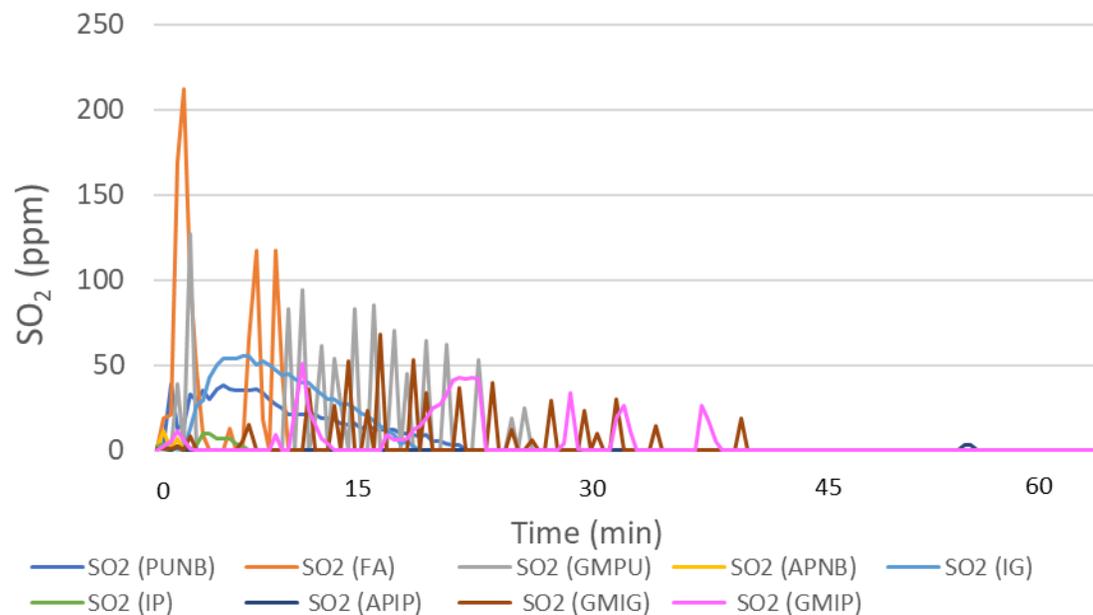
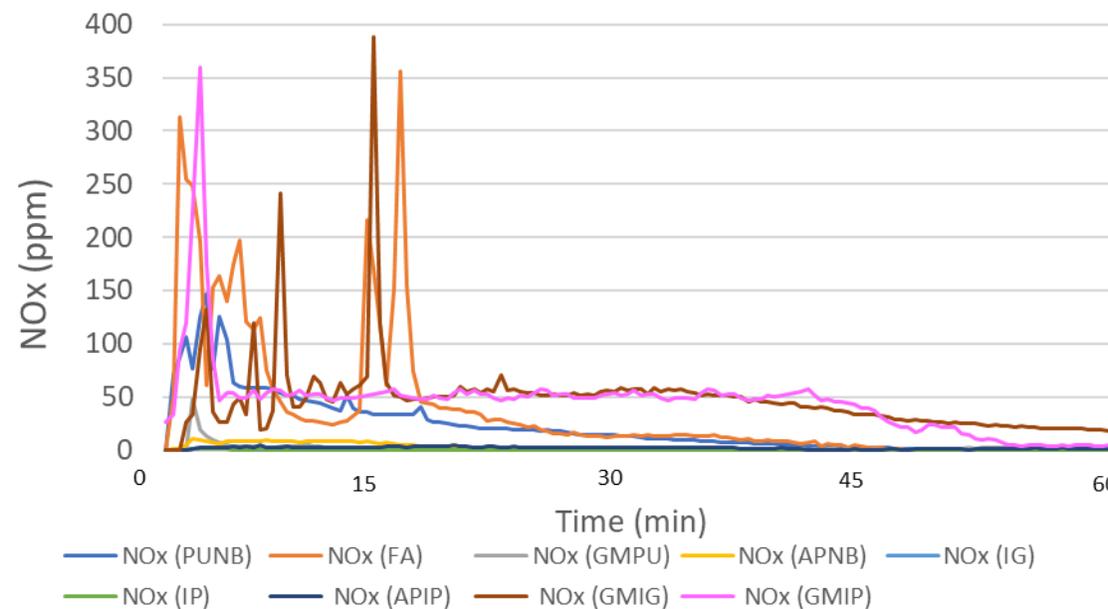
PAH
Acenaphthene + Fluorene
Acenaphthylene
Anthracene
Benzo[a]anthracene
Benzo(a)pyrene *
Benzo[b]fluoranthene *
Benzo[g,h,i]perylene *
Benzo[k]fluoranthene *
Chrysene
Dibenz[a,h]anthracene **
Phenanthrene
Fluoranthene
Indene (1, 2, 3-cd) pyrene **
Naphthalene
Pyrene
Σ PAHs

Gas (CO, O₂, NO_x, SO₂) emissions

Concentration of CO over time

Concentration of O₂ over time (%)

- Higher **CO emissions** (>5000ppm) in **green moulds** (attributed to coal → reductive environment). Consequently, higher O₂ consumption
- Followed by **organic binders** (mainly furan and alkaline phenolic)
- Less CO emission with **inorganic binders** (<3500ppm). The higher peaks are not immediate (non exothermic reactions)

Gas (CO, O₂, NO_x, SO₂) emissionsConcentration of SO₂ over timeConcentration of NO_x over time

- Higher peaks of SO₂ emissions (200ppm) in **FA system** (attributed to para-toluenesulfonic acid in hardener)
- **Green sand** systems showed the next highest SO₂ emissions (>50 ppm)
- Higher NO_x emissions (350ppm) in **FA system** and **green sand moulds**
- **Inorganic binders** release much less NO_x (1-2ppm)



- Significant **reduction in emissions (BTEX, PAH, gases)** is achievable using **inorganic binder** systems compared to other types
- **Improved workplace conditions.**
- Reduction of indirect costs.
- Lower environmental footprint.

More info about emission test results and GREENCASTING LIFE project

<https://www.azterlan.es/en/kh/greencasting-life>

✓ Papers (emissions measurements)

- ✓ *Eco-Friendly Inorganic Binders: A Key Alternative for Reducing Harmful Emissions in Molding and Core-Making Technologies*
- ✓ *Assessment of Harmful Emissions from Multiple Binder Systems in Pilot-Scale Sand Casting*
- ✓ *Green industrial scale casting production using engineered molding materials: Sustainable strategies to reduce process gas emissions*

✓ Email:

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