MATERIALS WEEK EUROPE

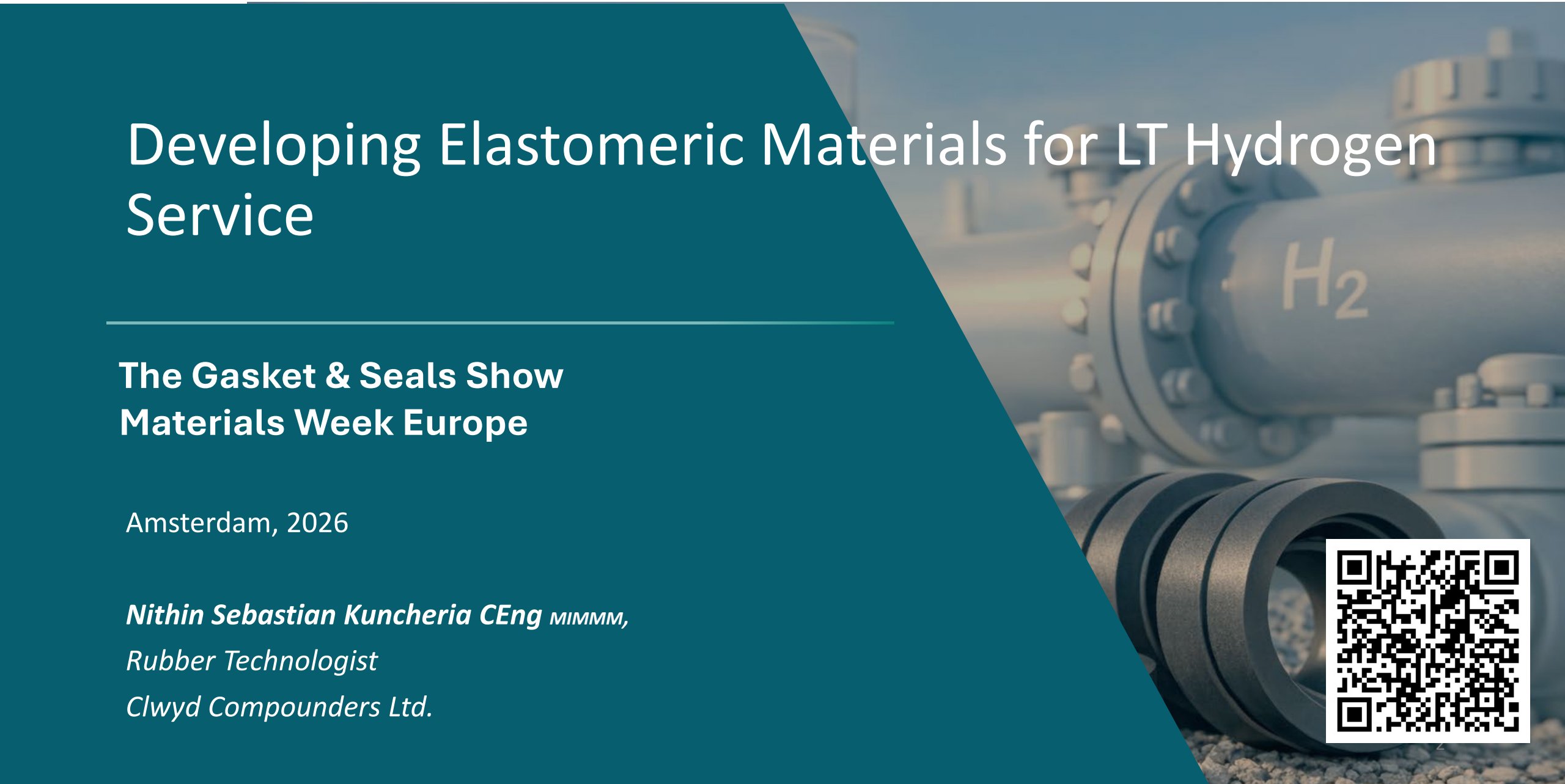
The next speaker is...

Nithin Kuncheria
Rubber Technologist
Clwyd Compounders

Developing Elastomeric Materials for LT Hydrogen Service

Scan below for Conference Agenda

Developing Elastomeric Materials for LT Hydrogen Service



The Gasket & Seals Show
Materials Week Europe

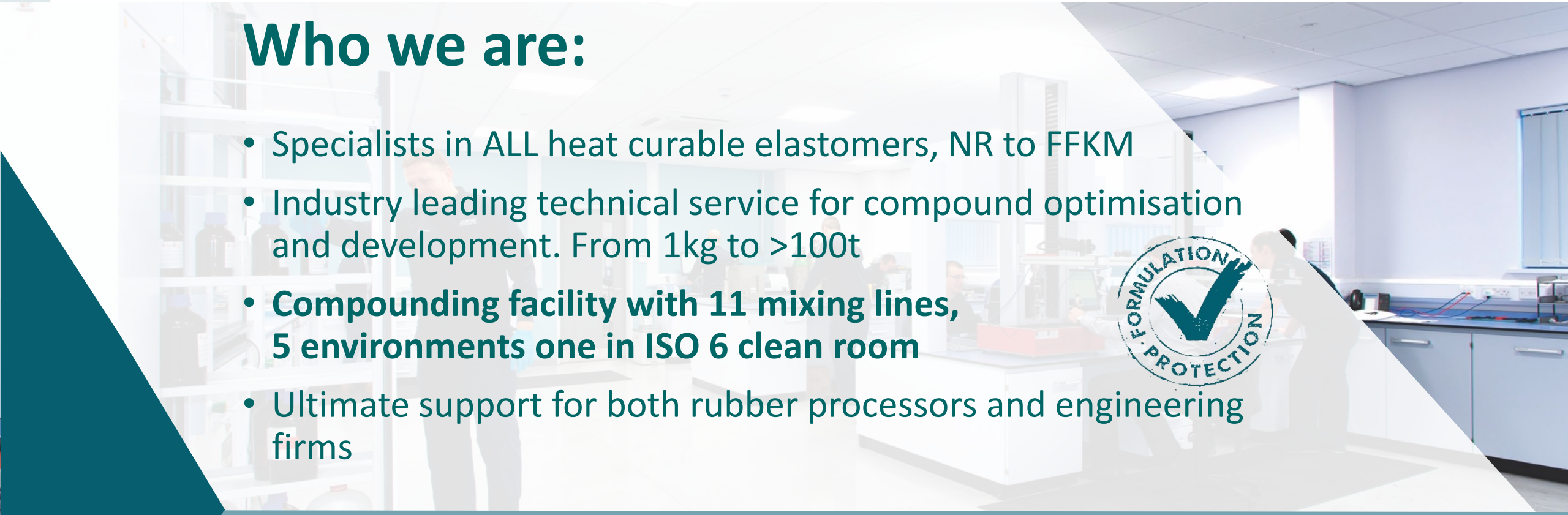
Amsterdam, 2026

Nithin Sebastian Kuncheria CEng *MIMMM,*
Rubber Technologist
Clwyd Compounders Ltd.

Elastomeric Compounding Specialists

Who we are:

- Specialists in ALL heat curable elastomers, NR to FFKM
- Industry leading technical service for compound optimisation and development. From 1kg to >100t
- **Compounding facility with 11 mixing lines, 5 environments one in ISO 6 clean room**
- Ultimate support for both rubber processors and engineering firms



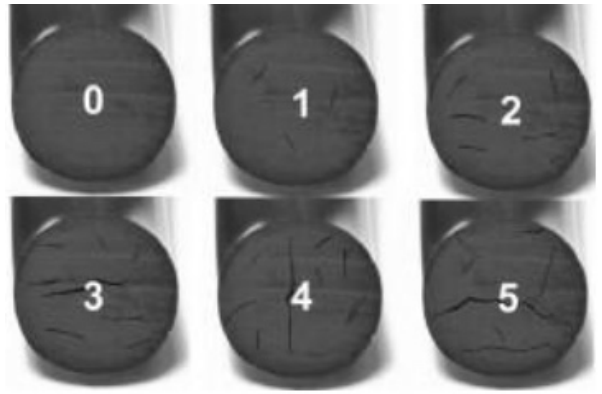
We offer a comprehensive compounding service, from Formulation to Application.

Challenges around elastomers ?

Hydrogen is the smallest molecule

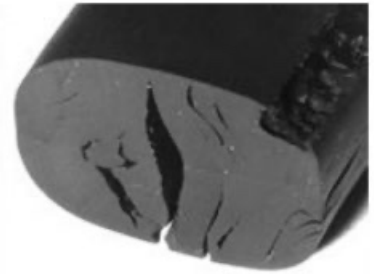
High diffusivity /permeation & Swelling

Extreme temperature ranges required

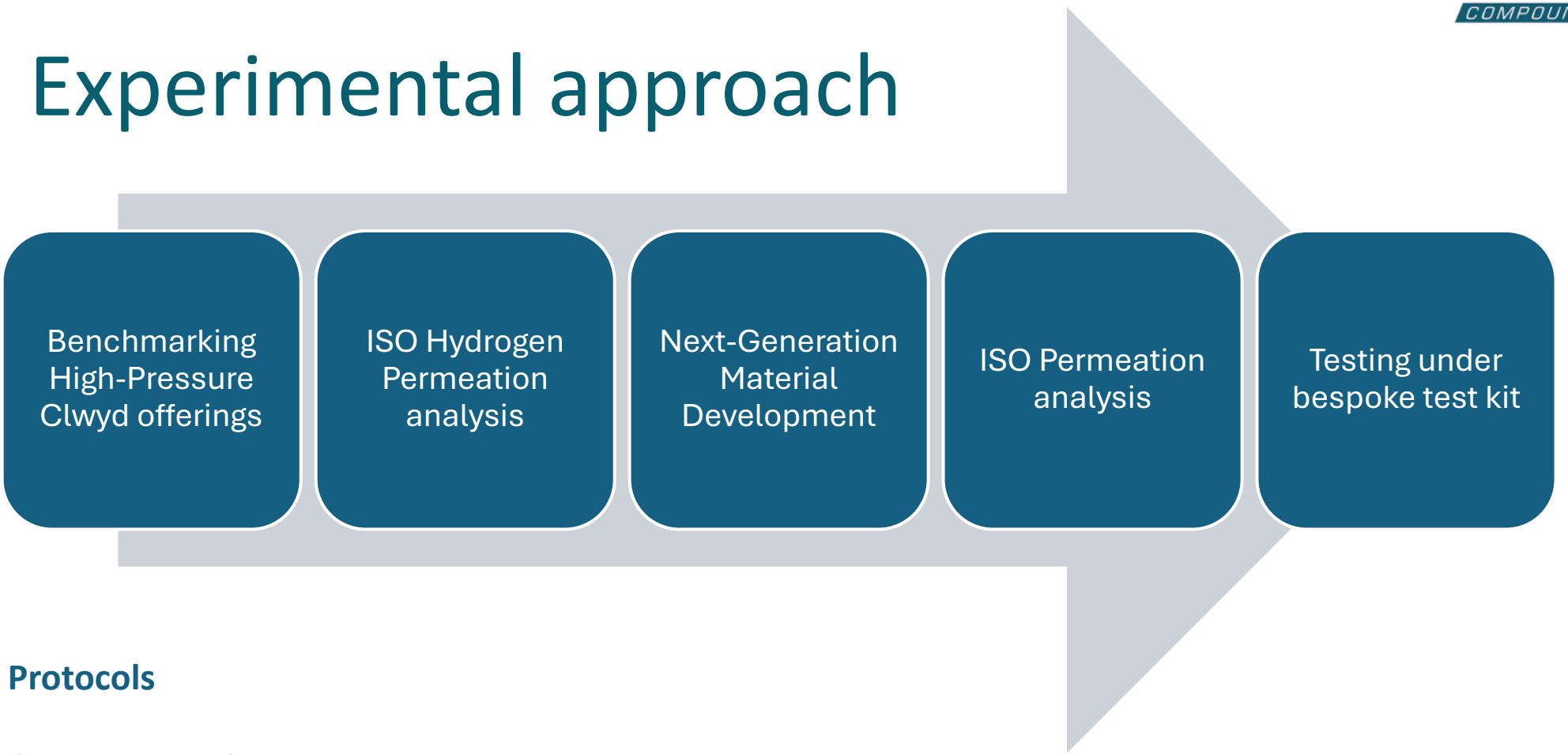


Additional Challenges

- New PFAS regulations
- High pressure applications requiring RGD capabilities.
- Lack of service validated test methodologies



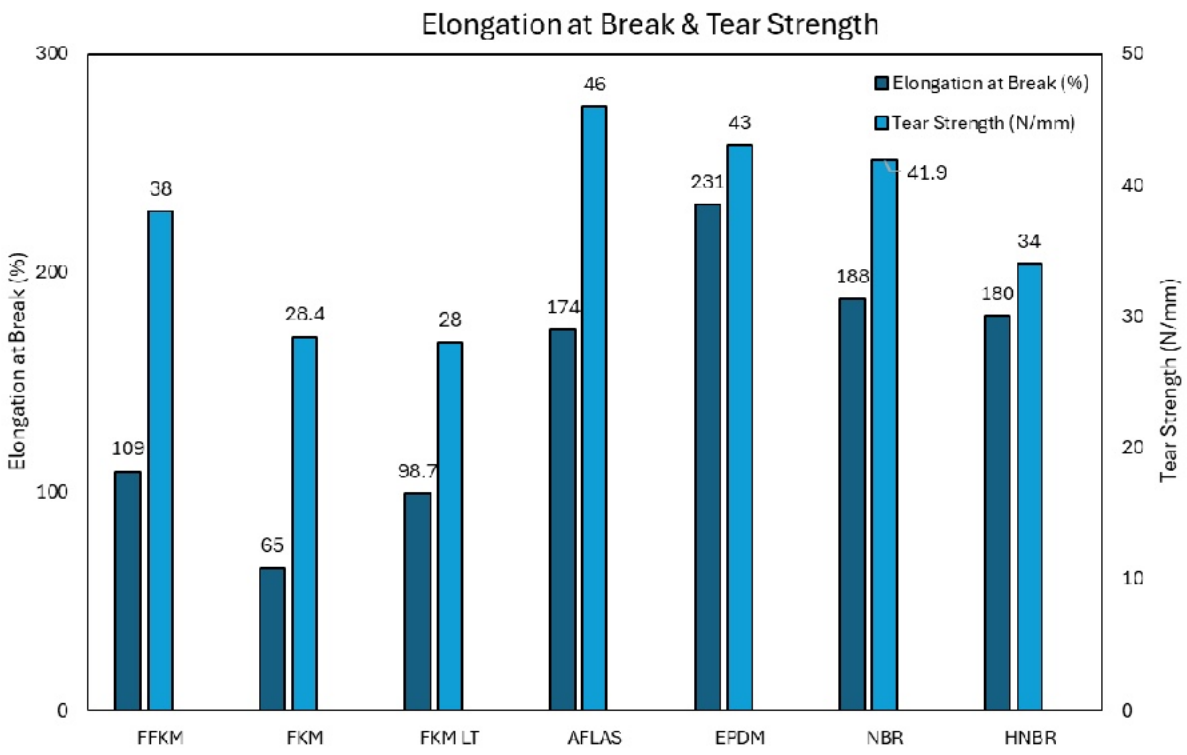
Experimental approach

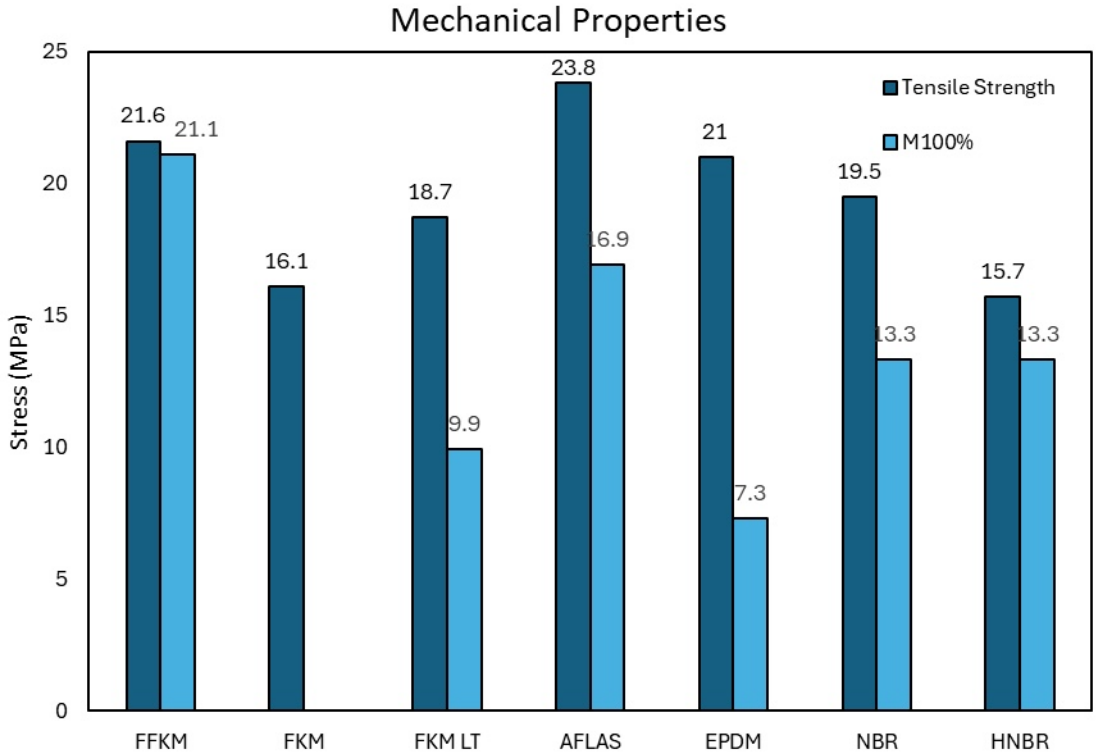


Testing Protocols

- Tensile properties & Compression set
- Heat Ageing properties
- DSC for glass transition temperature (T_g).
- H2 permeation as per BS ISO 15105-1
- Processability with rubber process analyser.

Physical Properties

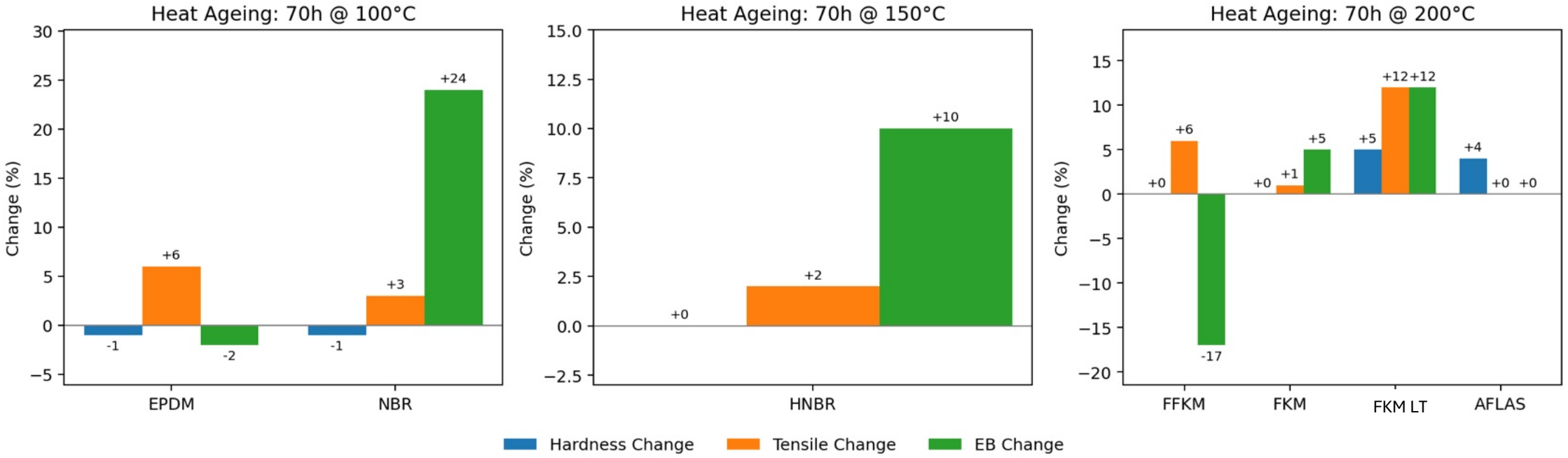




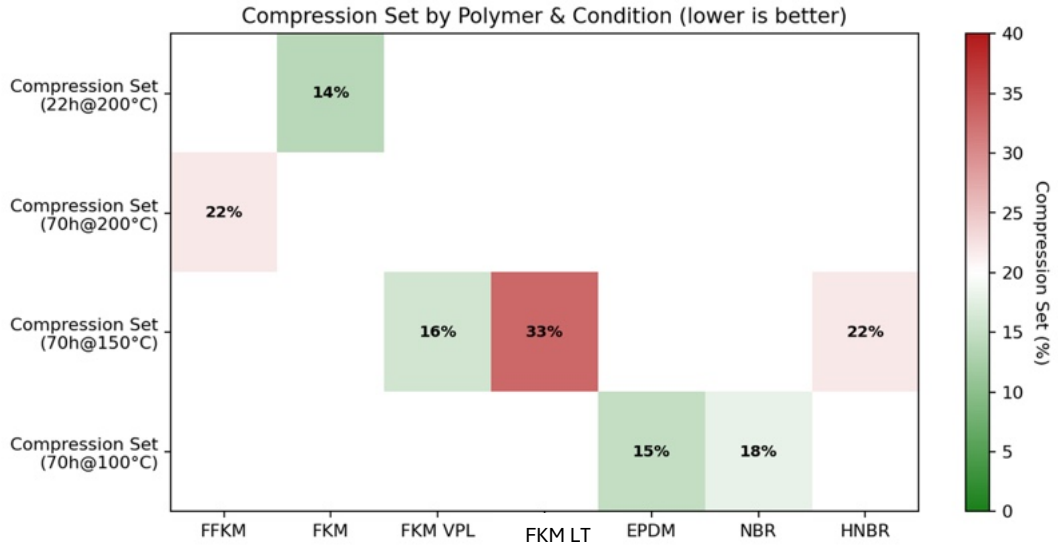
Mechanical Properties	FFKM	FKM	FKM LT	AFLAS	EPDM	NBR	HNBR
Hardness	93	94	95	90	91	91	85

- Benchmarking Clwyd's offerings already in field service for RDG applications.
- Essential to note these materials are more rigid tailored for high pressure application.

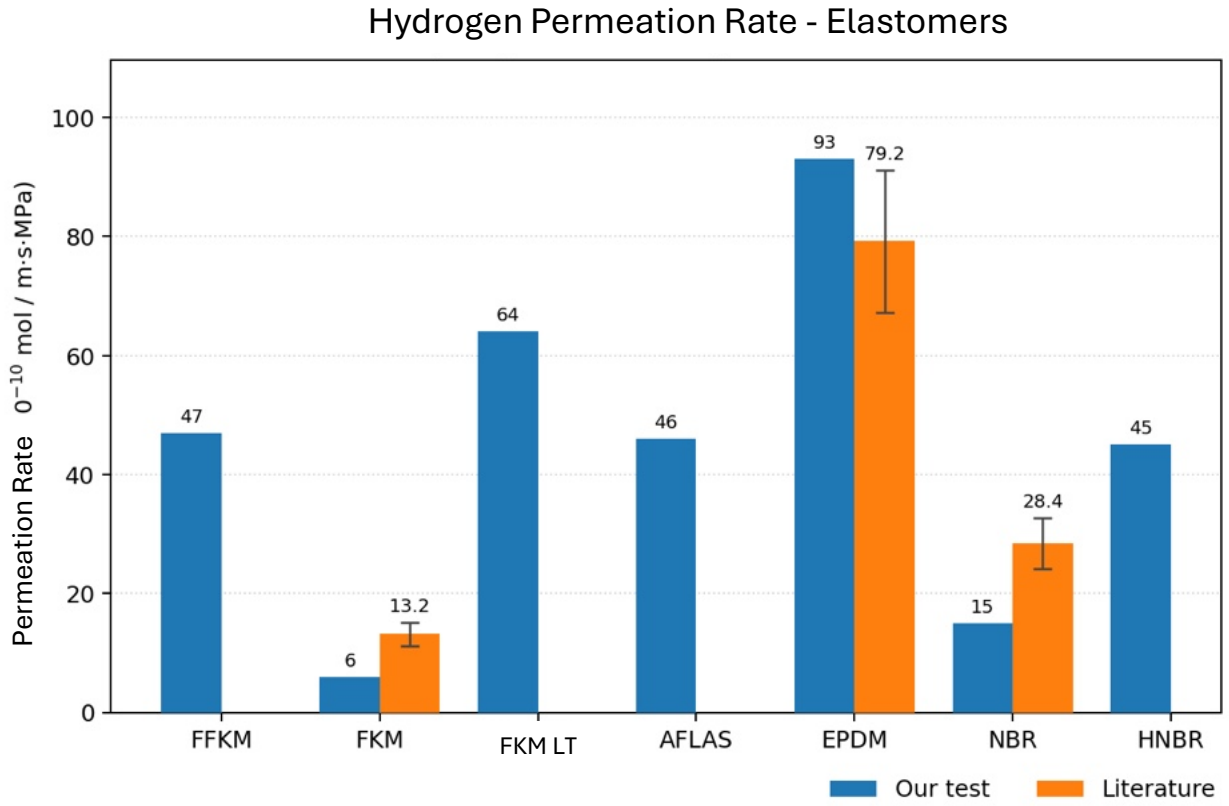
Compression set and Heat Ageing

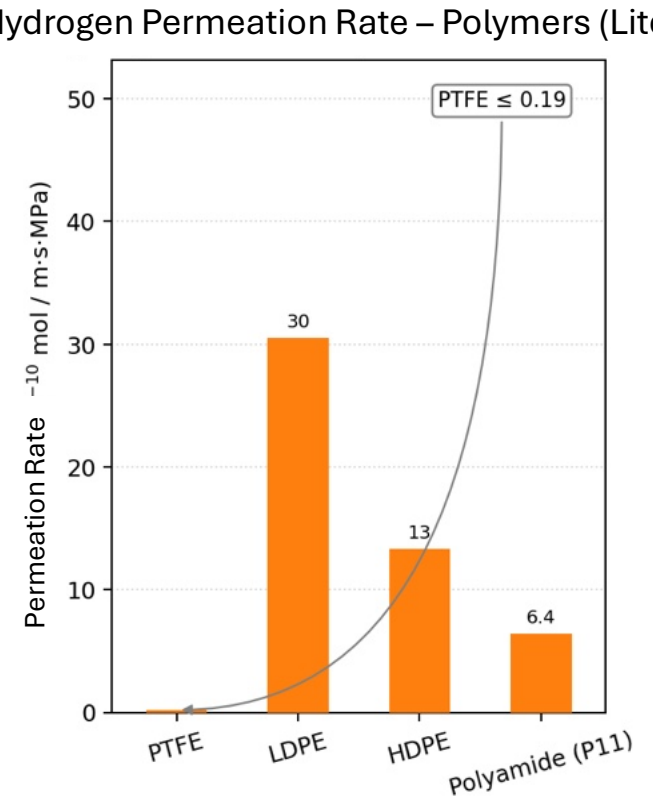


Choice of materials is influenced on service conditions like Temperature, Chemical in contact and final application.



H_2 Permeation data





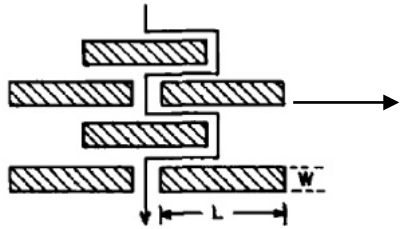
- Materials were tested via BS ISO 15105-1.
- FKM (copolymer) was performing the best in terms of permeation, followed by NBR.
- FKM comparable with other polymers available and highlights the importance of PFAS materials in $_2$ service applications.

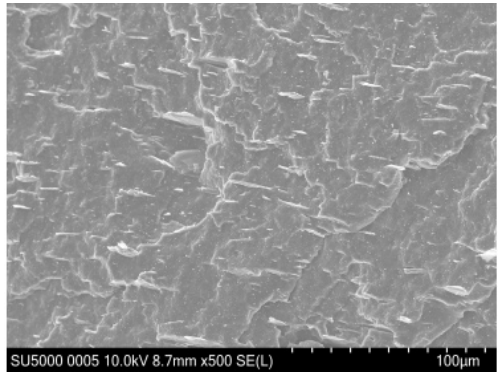
Reference:
Jung, J.K. et al. (2021) Curr. Appl. Phys., 21, 43–49.; Kanesugi, H. et al. (2023) Int. J. Hydrogen Energy, 48(2), 723–7 3 9 ; k, S. et al. (2016) Polymer Test., 49, 66–72.

Next generation Material Development

Performance & Regulatory drivers

- FKM offers excellent performance but faces future restrictions due to PFAS regulations.
- A compliant alternative is required with equivalent operation capability





Material innovation requirements

- Development of elastomers capable of low temperature performance in extreme environments.
- Replace VMQ for Low temperature applications?

Advanced material concepts

- Incorporating 2D materials (Graphene) to create a tortuous pathway.

R&D collaboration

- Bespoke test protocols under Innovate UK project
- Partnership with the University of Manchester

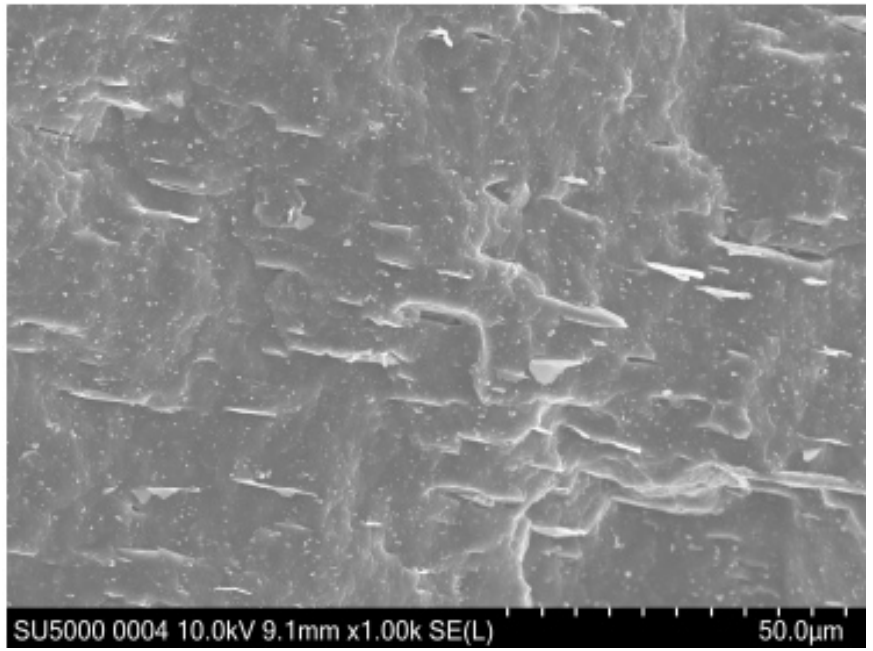
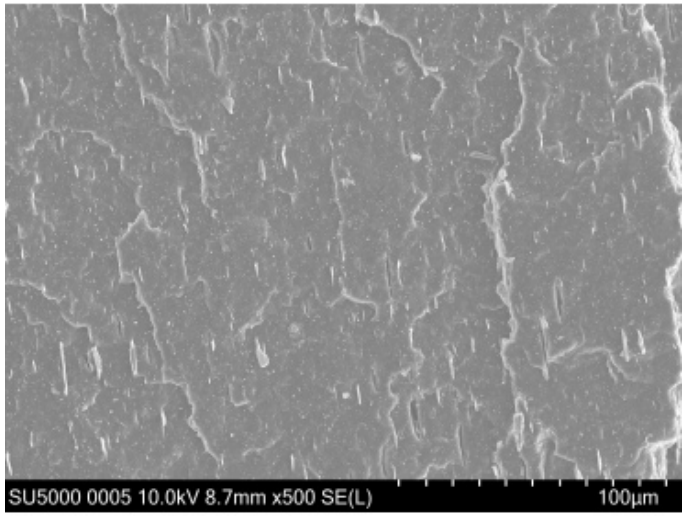
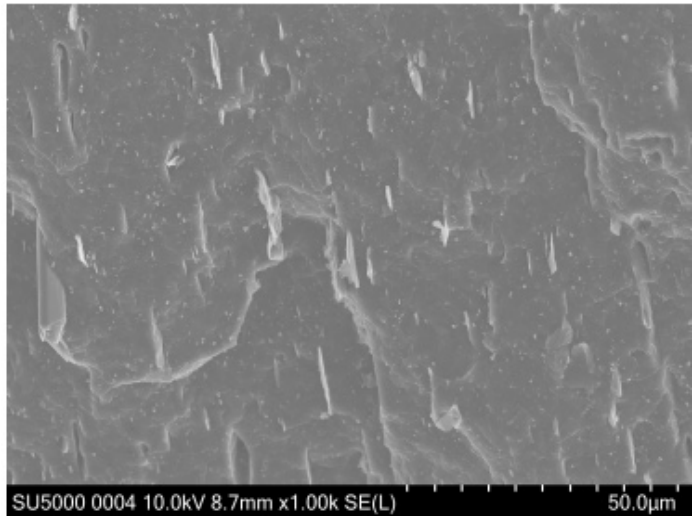
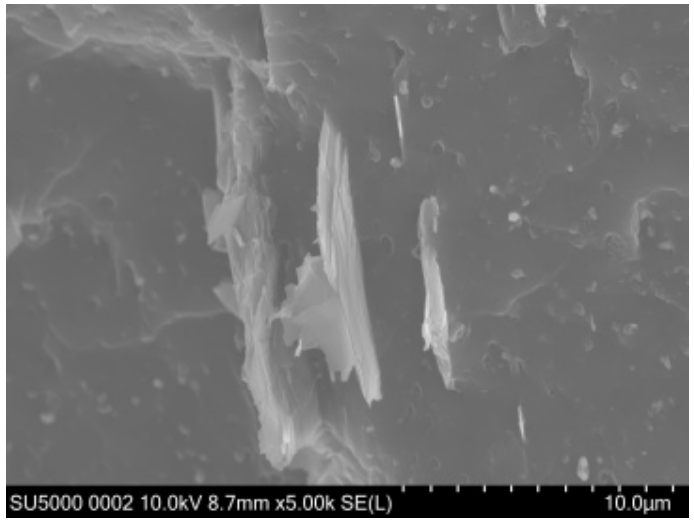


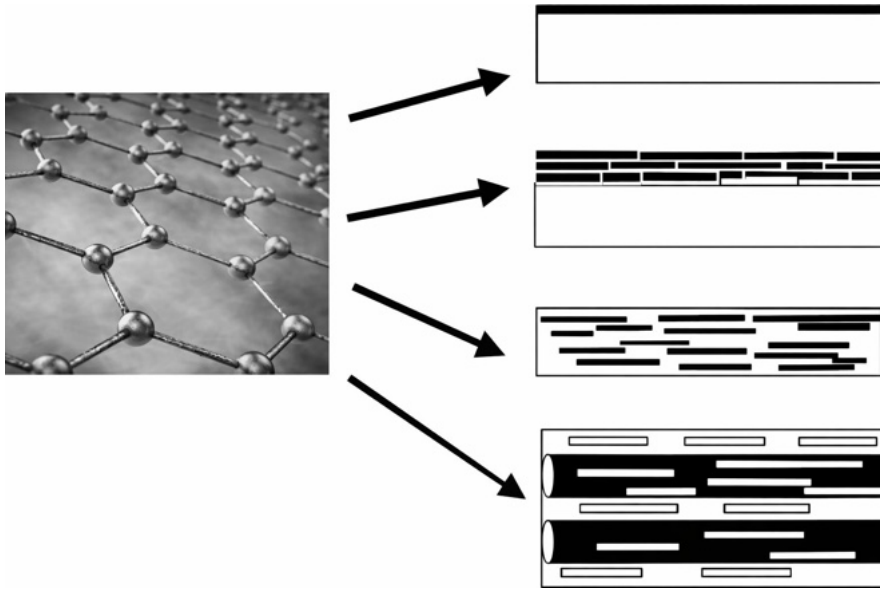
Fig: SEM images of Graphene Dispersed in Clwyd Rubber

Next generation Material Development

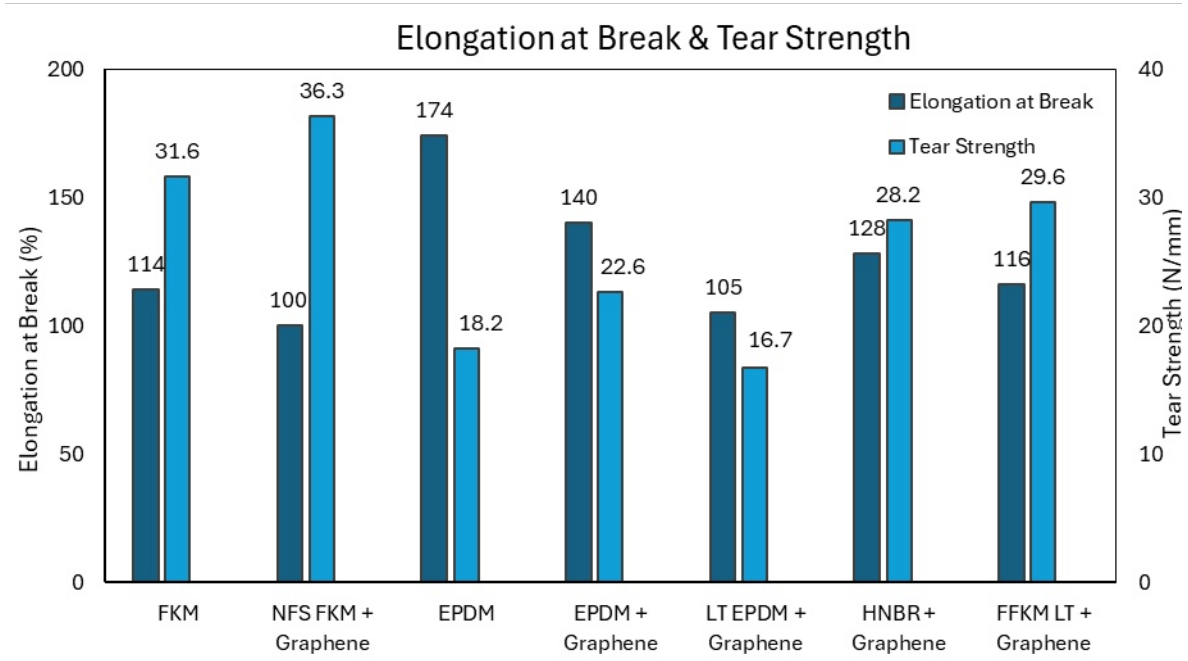


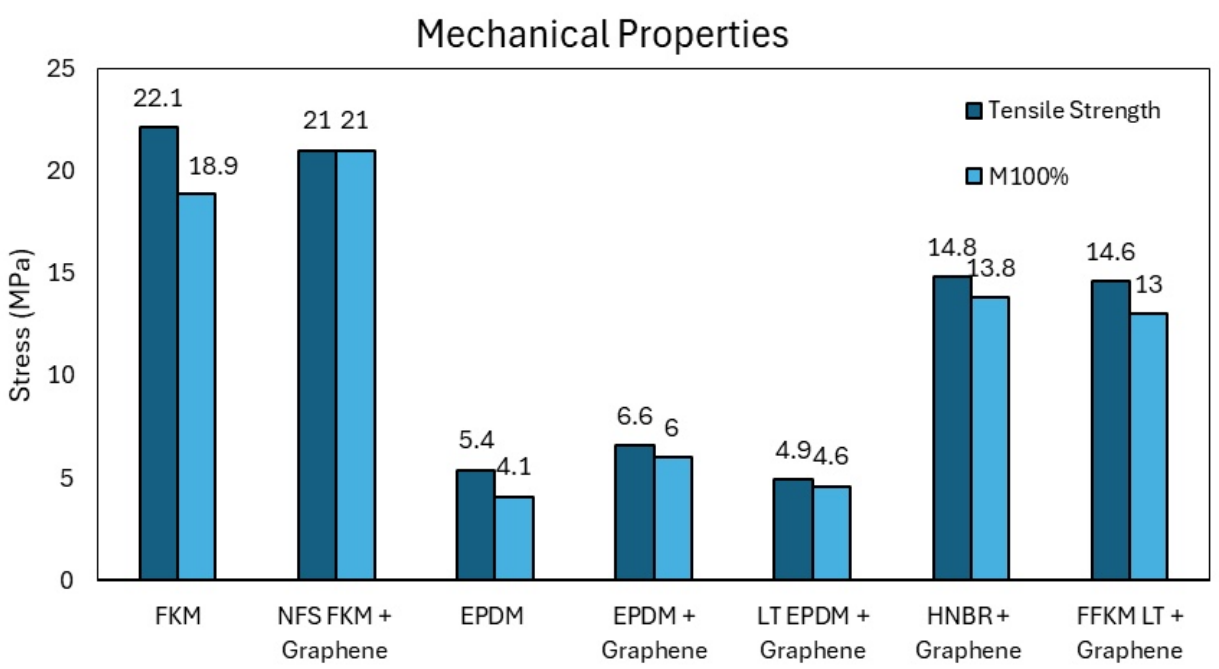






Physical Properties

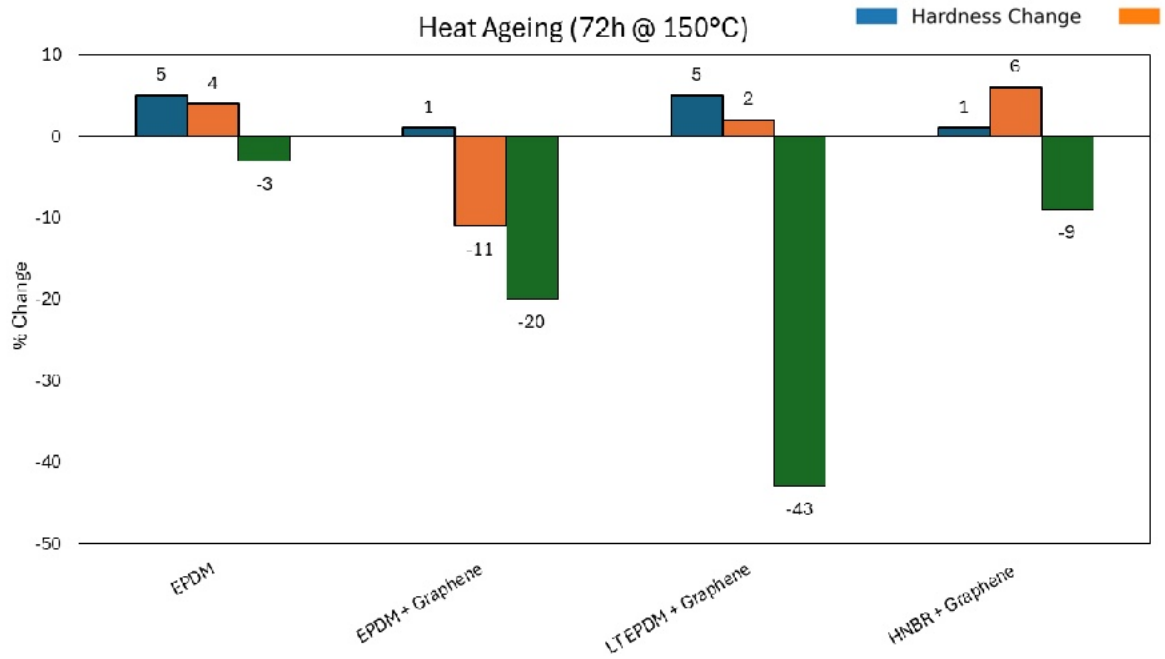


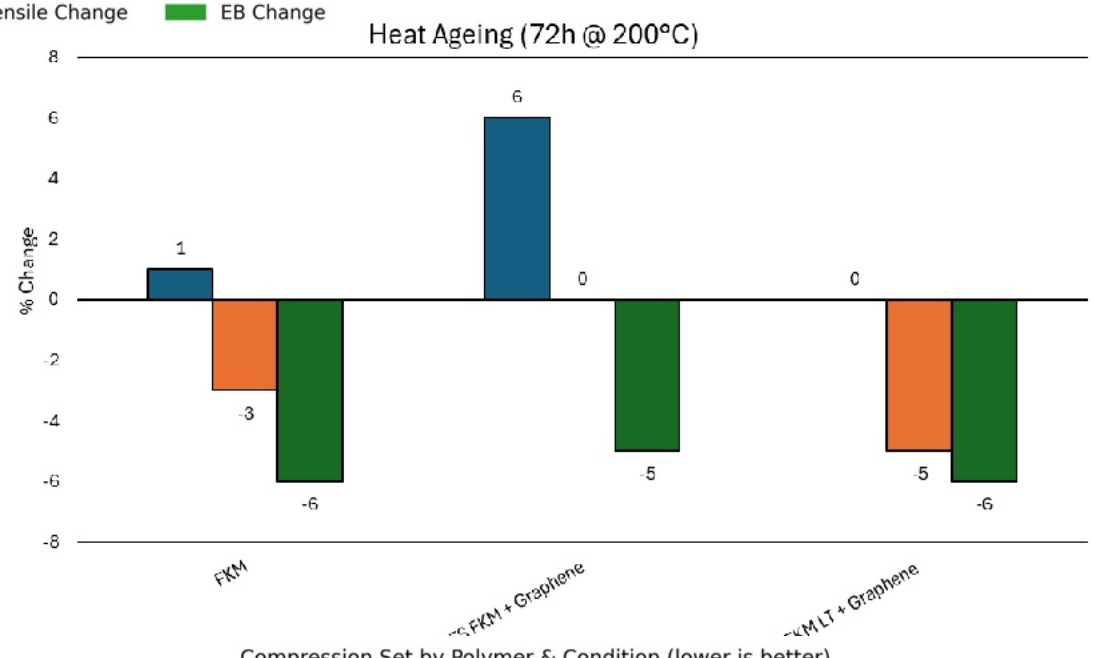


Mechanical Properties	FKM	NFS FKM + Graphene	EPDM	EPDM + Graphene	LT EPDM + Graphene	HNBR + Graphene	FFKM LT + Graphene
Hardness	94	95	89	92	91	89	94

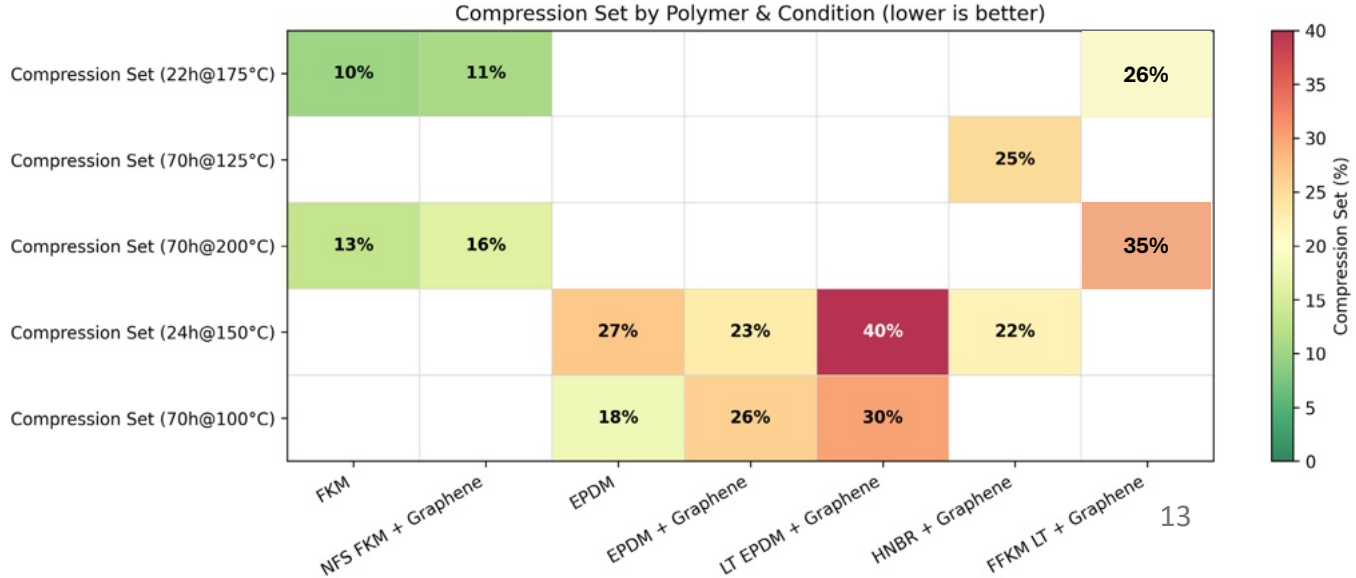
- The formulations were modified with 5% graphene loading.
- Improved properties were observed in terms of tear and modulus, due to the tortuous pathway created.

Compression set and Heat Ageing

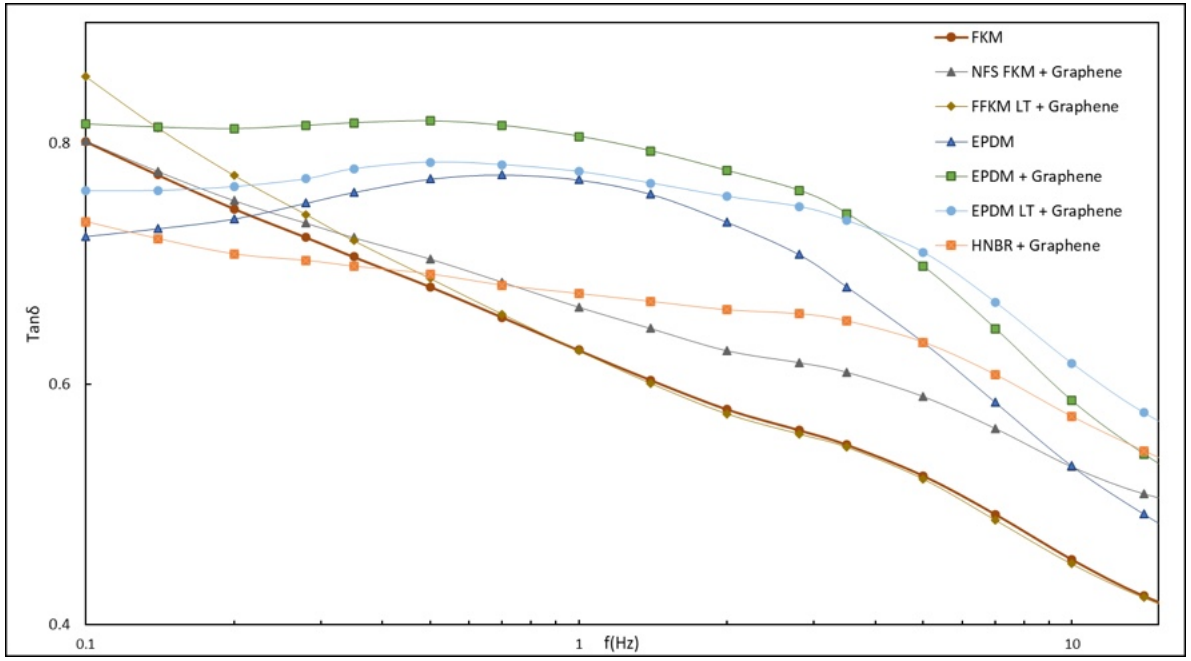




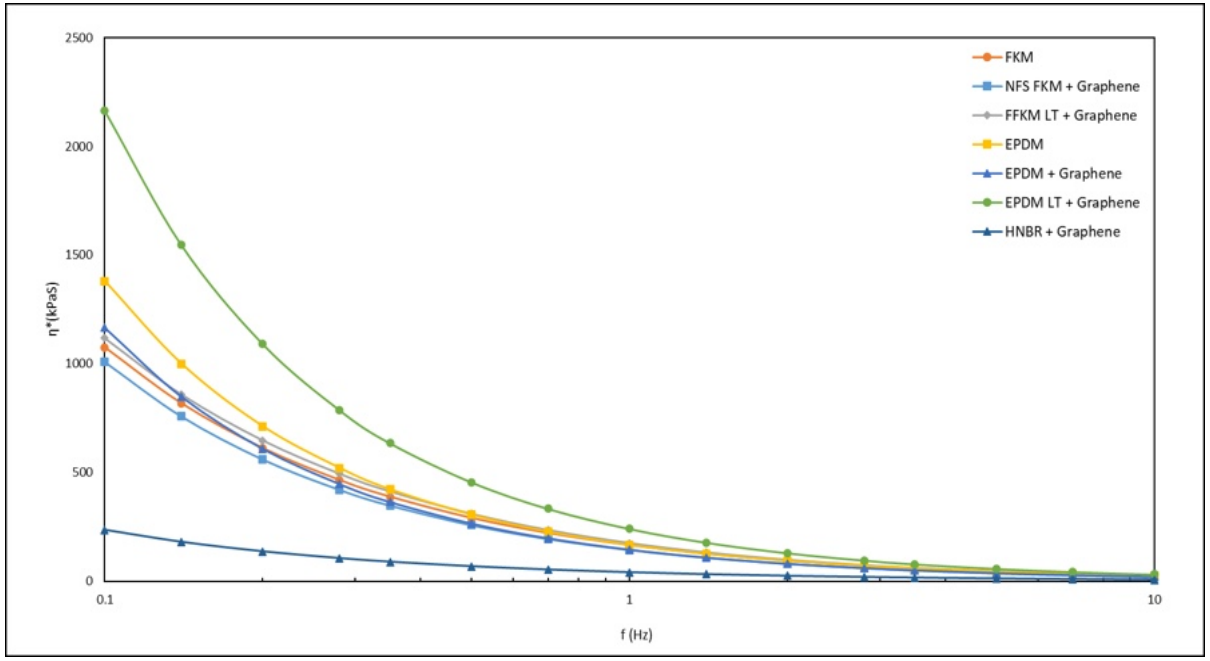
- Graphene has made impact on material properties.
- CS has slightly increased and Heat Aged EB has been decreased.
- FKM is not observed to be affected.



Processability



Frequency vs Tan δ

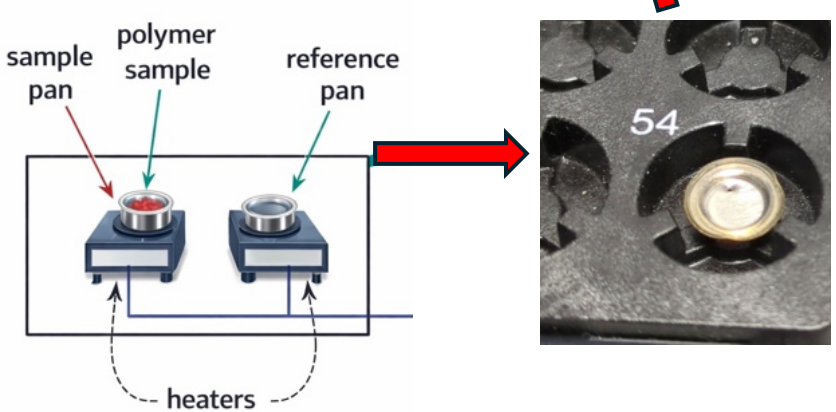


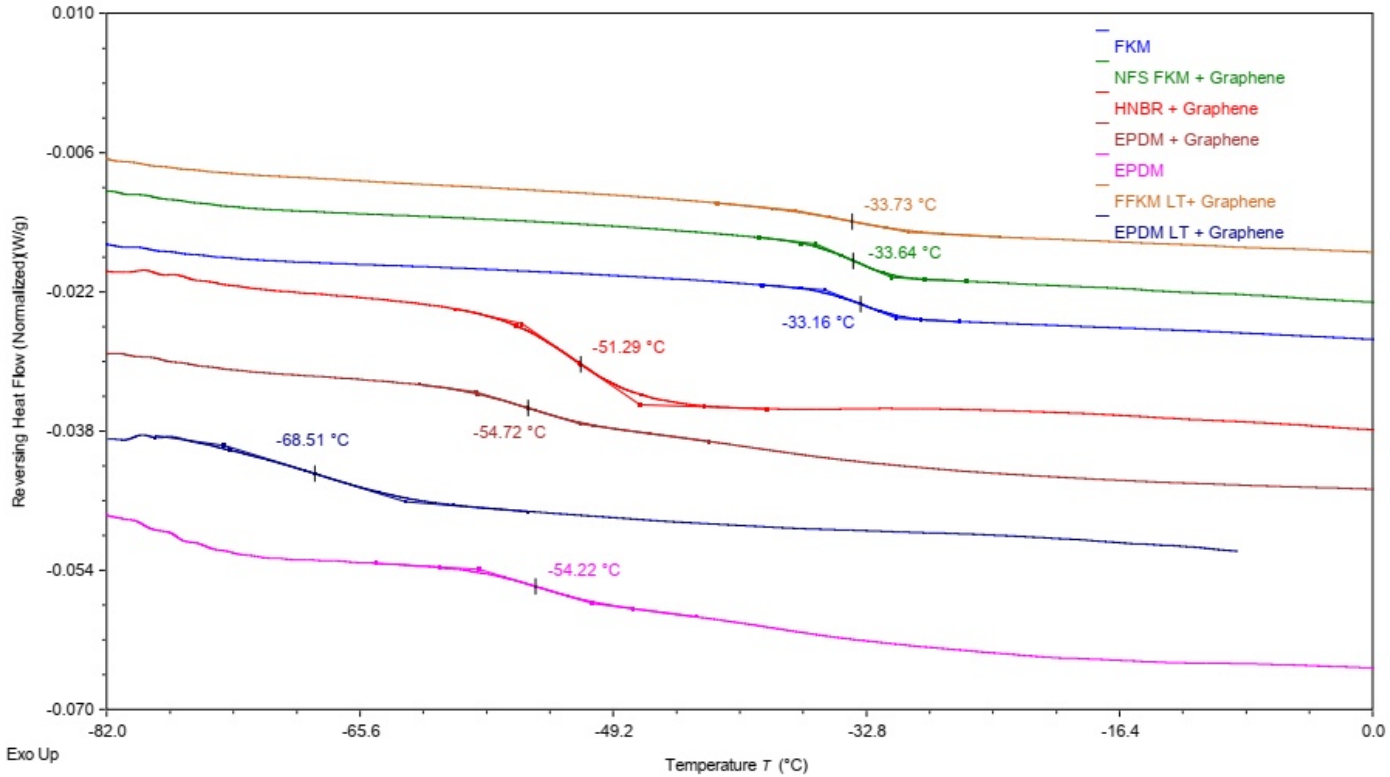
Frequency vs Complex viscosity (η*)

Frequency sweep @100 °C, 2.8 %

- Higher Tan delta at lower frequencies indicate better processability.
- Graphene dispersed materials are found to be comparable against original compounds, indicating good dispersion, not affecting processability.
- Lower complex viscosity indicates better mould flow and Graphene dispersed materials are comparable to original.

Low Temperature Properties-T_g

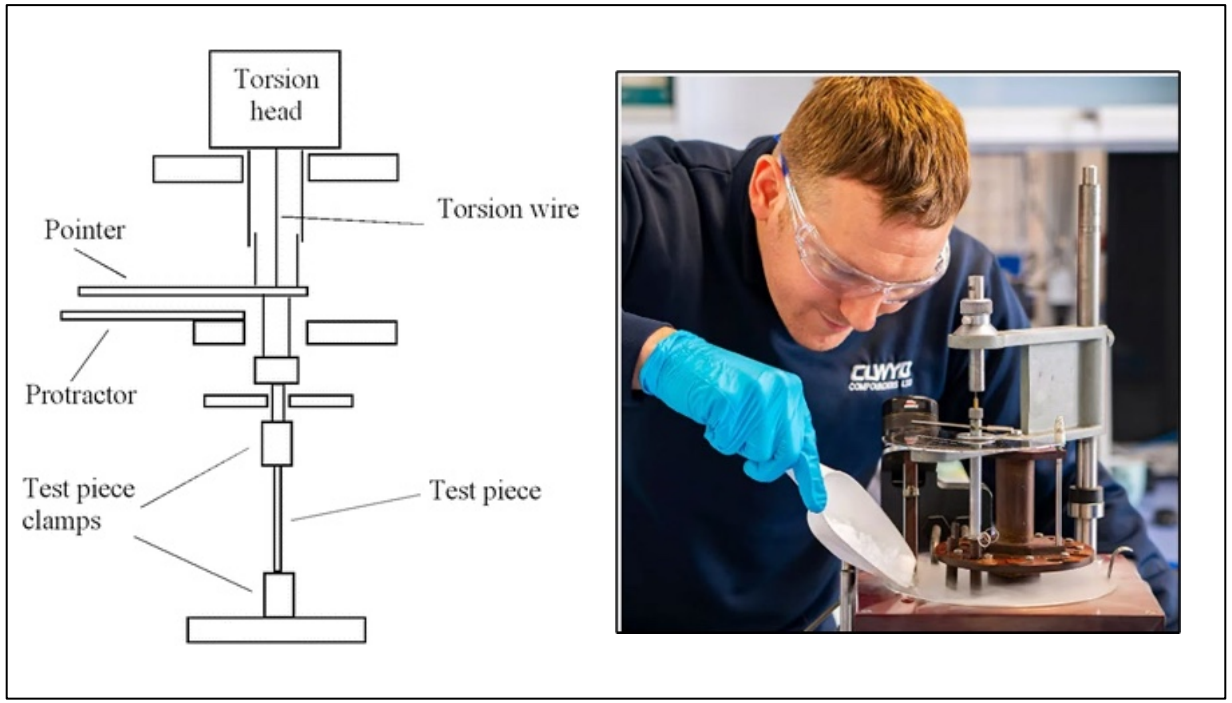




Glass Transition Temperature (T_g)

- DSC measures heat flow differences between a sample and a reference during a controlled temperature programme.
- EPDM LT Clwyd IP formulation is achieving a T_g of -68.5°C, potentially to replace VMQ in H_2 applications.

Low Temperature Properties

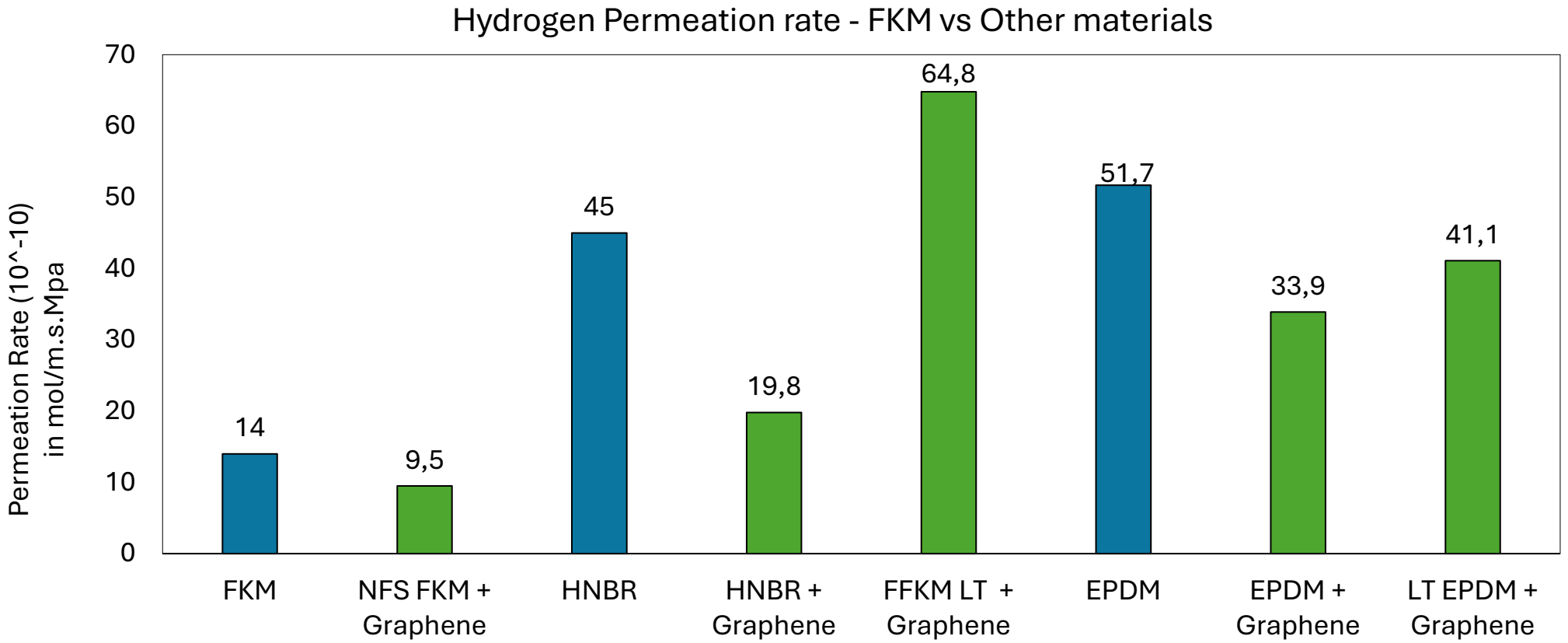


Gehman Test

Materials	°C at 70 Mpa Torsional Mod
FKM	-33.16
NFS FKM + Graphene	-33.64
EPDM	-40.7
EPDM + Graphene	-38.6
LT EPDM + Graphene	**-54.8**
HNBR + Graphene	-35.5
FFKM LT + Graphene	-26.3

- The Gehman test measures torsional stiffness as a function of temperature, starting from a low temperature.
- New LT EPDM compound demonstrate its improved low temperature capability with Gehman results for 70 MPa at **-54.8°C**.

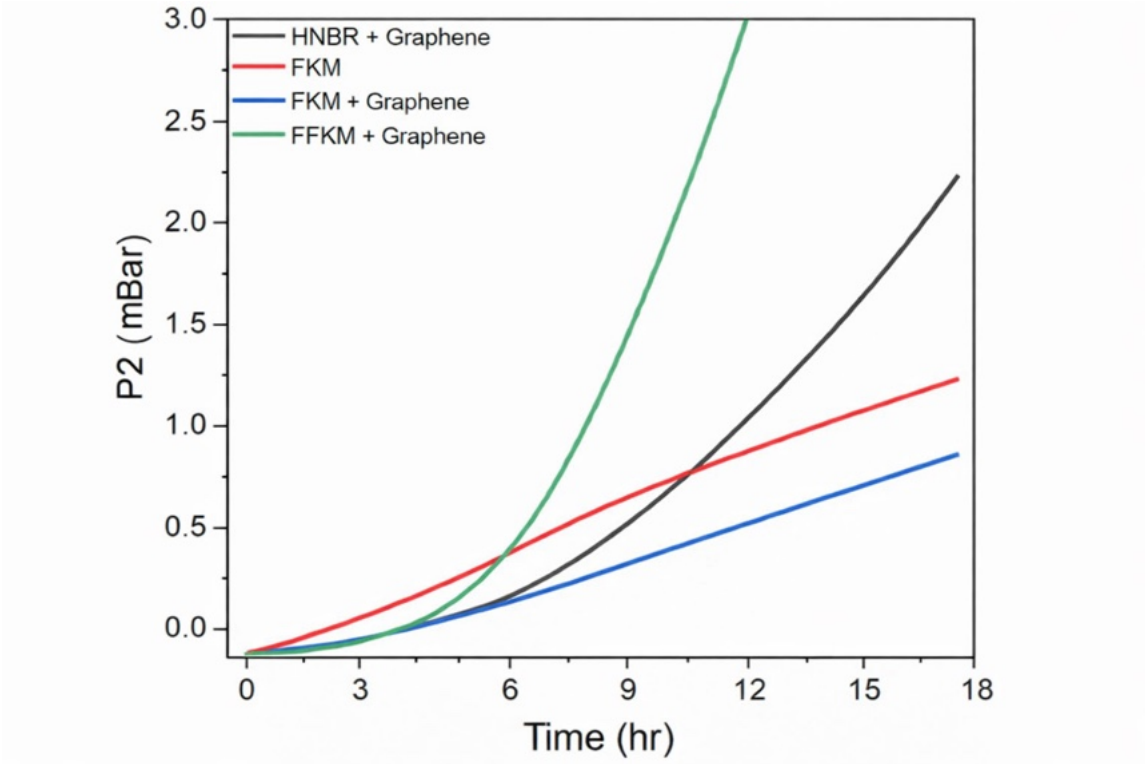
H_2 Permeation data



- Materials were tested via BS ISO 15105-1.
- Graphene Dispersed NFS FKM is found to be permeation rate is **31% reduced.**
- All materials have found to **improve permeation performance with Graphene.**

Innovate UK Partnership

H2 distribution and pump to get up to 200 bar



Permeation in CO_2, lower the curve at 15hrs, the better

- Next Generation test kit setup being setup at the University of Manchester funded by an Innovate UK grant.
- To test materials at varying pressures (upto 200 bar) and temperatures from -30° to +200°C.
- Initial testing under CO_2 prove that graphene does help in improving the permeation of the materials.

Conclusions

- High-pressure RGD-grade materials show strong potential for ⁉ service due to favourable diffusion characteristics
- Material selection should be based on the specific end application and service conditions
- Newly developed NFS FKM materials demonstrate performance comparable to existing options
- Graphene-dispersed materials indicate enhanced diffusion resistance by creating a more tortuous permeation path
- These graphene-dispersed materials also exhibit satisfactory mechanical properties and good processability, confirmed through RPA testing
- Innovation in material development is essential for next-generation applications, particularly low-temperature environments where alternatives to VMQ are required. Clwyd IP EPDM has shown promising performance in this area
- Bespoke test methodologies tailored to final service conditions are critical and may vary depending on the application

Thank You!

Specialists in Custom Rubber Compounds

Enquiries

info@clwydcompounders.com

T. +44 1978 810551

Sales Director

Ian Haywood

ih@clwydcompounders.com

Mob. +44 7968 035063

www.clwydcompounders.com