



Enhancing FeCrAlloy® Substrate for Improved Surface Characteristics

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INTRODUCTION

Methanol production via CO₂ hydrogenation is a promising pathway for **SUSTAINABLE SYNTHETIC FUELS**, but high production costs continue to limit its commercial viability compared to methanol derived from fossil fuels [1]. Along with production of hydrogen and capture of CO₂, high operation condition also contributes to high cost for the production of E-Methanol. Structured catalysts, particularly wash-coated metallic monoliths, are valued for their **IMPROVING PERFORMANCE** and **REDUCING PRESSURE DROP** in heterogeneous catalysis. However, poor coating adhesion and mechanical instability remain critical challenges, leading to spalling and reduced performance during operation.

OBJECTIVE

This work seeks to overcome these limitations by optimise pre-treatment methods to enhance surface roughness, to facilitating better surface for catalyst anchoring thus improving coating adhesion.

METHODOLOGY

The surface roughness of FeCrAlloy® can be increased through appropriate pretreatment methods which enhance the adhesion of catalytic coatings thus enhancing the durability and catalytic efficiency [2]. Improvement of surface characteristic measured in terms of BET surface area as surface roughness increases with increase in BET surface area [3].

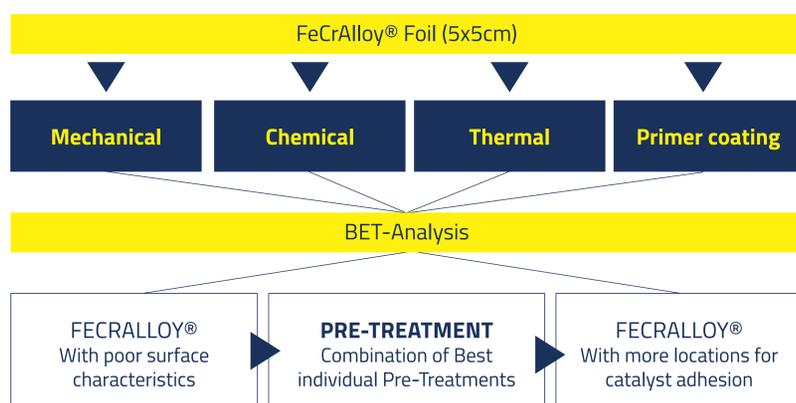


Fig. 1: Illustration of research matrix

Individual samples were subjected to a systematic sequence of pre-treatment methods, followed by BET surface area measurement to evaluate the impact of each treatment.

| Technique | Process | Purpose |
|-----------------------------|--|---|
| Mechanical (MP) | Abrasion with 240- and 400-grit sandpaper. (e.g., MP_240) | Increase surface roughness. |
| Chemical (CP) | Etching for 30 min (CP1) and 2 hrs (CP2) with: 30% wt. NaOH and 30% wt. H ₂ SO ₄ . (e.g., CP1_H ₂ SO ₄) | Enhance porosity through oxidation of metal alloy. |
| Thermal (TP) | Calcination at 900–1000°C for 5–20 hours. (e.g., TP900_5) | Restructure surface through oxide layer formation. |
| Primer Coating (PC) | Composition: Boehmite primer with (PC1) and without (PC2) 5 wt.% PVA. (e.g., PC1_10) Application: Dip-coated, dried, and calcined at 600°C. | Create uniform pore sites to facilitate catalyst anchoring. |
| Combination Strategy (Comb) | Best-performing methods from MP, CP, TP, and PC were combined (Comb_Best of all) | Optimize surface properties for coating applications. |

REFERENCES

- Borisut & Nuchitprasittichai, 2019, Methanol Production via CO₂ Hydrogenation Sensitivity Analysis and Simulation Based Optimization
- Diaz, Y., Sevilla, A., Mónaco, A., Méndez, F.J., Rosales, P., García, L., Brito, J.L., 2013. Metallic monoliths of AISI 304 stainless steel, aluminum, FeCrAlloy® and brass, coated by Mo and W oxides for thiophene hydrodesulfurization
- U. Ulusoy & M. Yekeler, 2003, Characterization of Surface Roughness of Calcite by BET and Surtronic 3 + Techniques

SPECIFIC SURFACE AREA ANALYSIS

The pre-treated foil samples were degassed at 200°C for overnight to remove any adsorbed contaminants.

A Microtrac Belsorp Mini X physisorption device is used for the Nitrogen adsorption isotherms (recorded at liquid nitrogen temperature-196°C).

The BET surface area was calculated from the adsorption data using the BET equation in BELMASTER software.

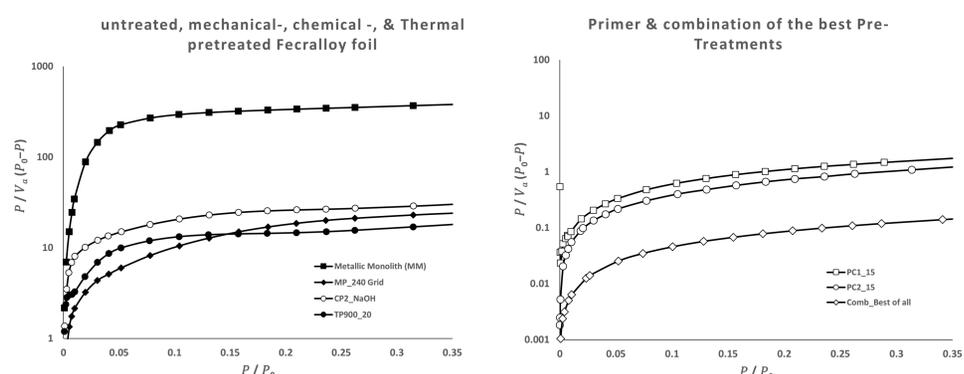


Fig. 2: BET adsorption curves for (a) untreated vs. the best mechanical, chemical, and thermal pre-treated samples and (b) the best primer-coated sample vs. the optimised combination of all treatments.

KEY FINDING

Optimised pre-treatments significantly improved FeCrAlloy® surface characteristics, achieving a high BET surface area and strong adhesion. Chemical and thermal pre-treatments: **NaOH FOR 2 HOURS AND 900°C CALCINATION FOR 20 HOURS** were critical for creating porosity and alumina whiskers. Primer coating with PVA provided uniform pore sites, achieving the highest individual bet surface area of 1.3014 m²/g. Achieved **11.011 m²/g** BET surface area with a combined strategy, a **1000x improvement** over untreated foil (0.007 m²/g). Remarkably close to the results of Diaz et al. (12–16 m²/g), he achieved only this result after both primer and catalyst coatings [2], showcasing the efficiency of the pre-treatment process.

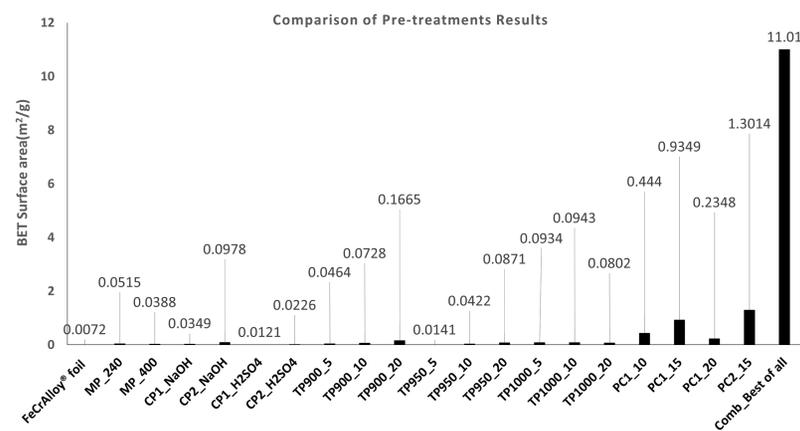


Fig. 3: BET surface area results for individual and combined pre-treatment methods.

RESEARCH OUTLOOK

Investigation on the effect of different alumina materials and binders on surface improvement of FeCrAlloy® foil. Experimental investigation to coat the catalyst to analyse the adhesion on the improved surface.

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