



# BIOMASS EXTRACTS INHIBIT METAL CORROSION

**EMEKA E. OGUZIE**

**FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, NIGERIA**



1<sup>st</sup> International Conference of  
TWAS Young Affiliates Network



August 22 – 24, 2017  
Rio de Janeiro,

# CORROSION

---

- Corrosion is the gradual deterioration of materials (usually metals) by reaction with their environment.
- It is a natural process, in which the refined metal is converted to a more chemically-stable form, such as its oxide, hydroxide, or sulfide. (The most common example is rusting of iron)
- All refined metals can corrode..... A metal has no hiding place



<https://en.wikipedia.org>

# CORROSION OCCURS IN MANY SECTORS.....



[Keywordsuggest.org](http://Keywordsuggest.org)



[cz.depositphotos.com](http://cz.depositphotos.com)



[linkedin.com/pmolly-keesling](http://linkedin.com/pmolly-keesling)



<http://www.civilengineeringforum.me>



<http://danieli.wikidot.com>



<http://allthingsnuclear.org>

# DIRECT COST OF CORROSION

---

**Global corrosion costs: \$2.3 Trillion annually** ([www.nace.org](http://www.nace.org))



**USA corrosion costs: \$1.1 Trillion annually** ([www.g2mtlabs.com](http://www.g2mtlabs.com))

**India corrosion costs: \$100 Billion annually** ([economictimes.indiatimes.com](http://economictimes.indiatimes.com))

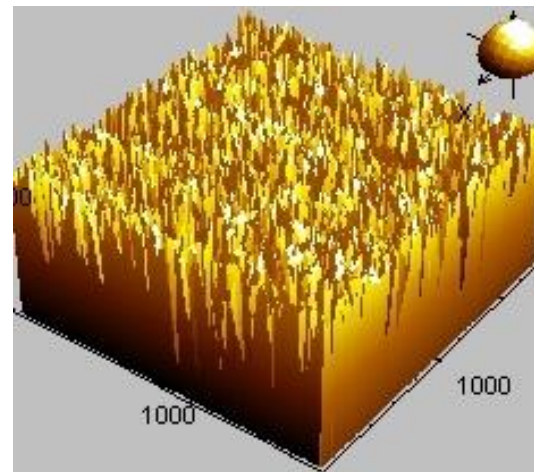
# CORROSION CONTROL

- **Modifying the metal surface** (Alloying & Coating )
- **Modifying the environment** (Addition of inhibitors)

The use of corrosion inhibitors (CIs) is an effective and economical way to mitigate the corrosion rate, protect metal surfaces against corrosion in aggressive fluid environments.

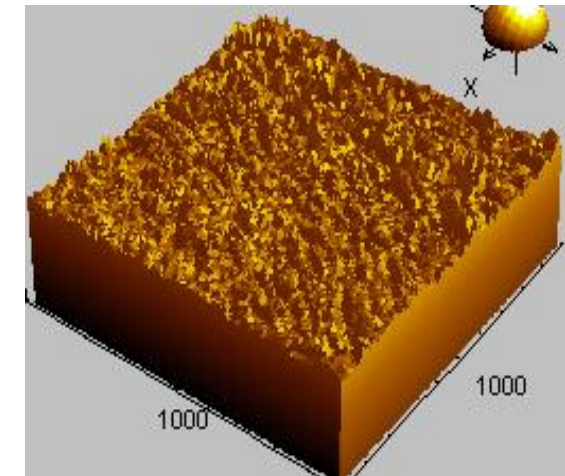
## ORGANICS

- Fatty amides
- Pyridines
- Imidazolines
- 1,3-azoles
- Polymers
- Amines, ETC



**EXPOSED METAL SURFACE**  
Corroded surface

**ADD  
INHIBITOR**



**SURFACE IS PROTECTED**

*Oguzie et al., JCIS*

# OPPORTUNITIES

- Reduce corrosion costs
  - Lower risk of failure
  - Develop new expanded markets
- 

The corrosion inhibitors production chemicals market was about \$6.3 Billion in 2015 (CAGR 5%)  
*.....A Viable investment opportunity*

# CURRENT CONCERNS

- Toxicity and known hazardous effects of most corrosion inhibitors
- Recent concerns about the environment
- Costs

**These provide sufficient motivation for development of new classes of benign, inexpensive yet effective additives, specifically designed to address future environmental and safety needs.**



# OUR APPROACH

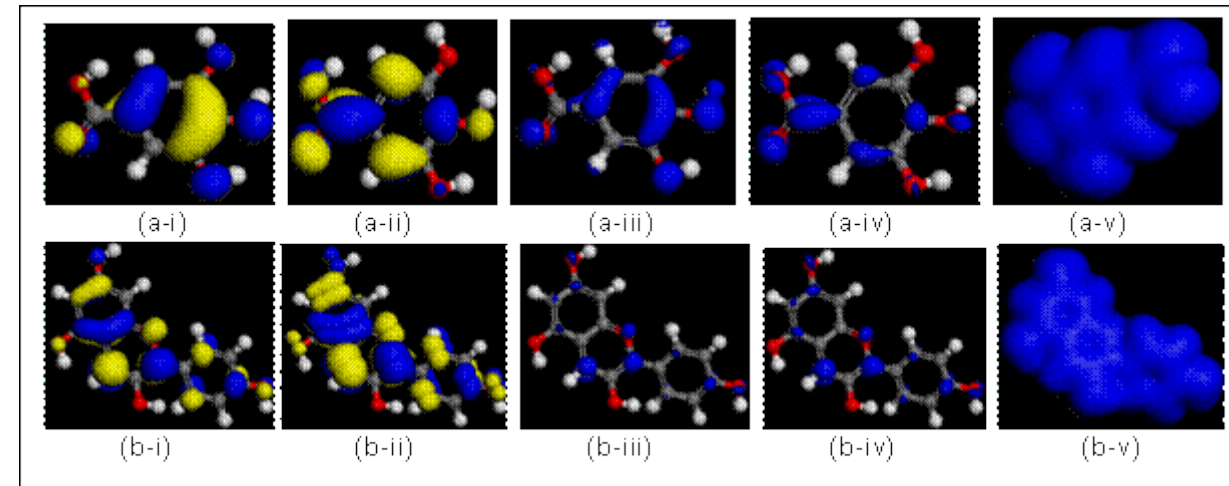
We are developing a new class of low-cost, eco-friendly anticorrosion additives from biomass extracts

## JUSTIFICATION:

- The abundant phytochemical constituents of plant biomass extracts are sources of a wide range of organic chemicals of prospective industrial significance.
- The extracts contain several phytochemical compounds with molecular and electronic structures bearing close similarities with those of conventional synthetic corrosion inhibitors



<http://www.biopelletmill.com>

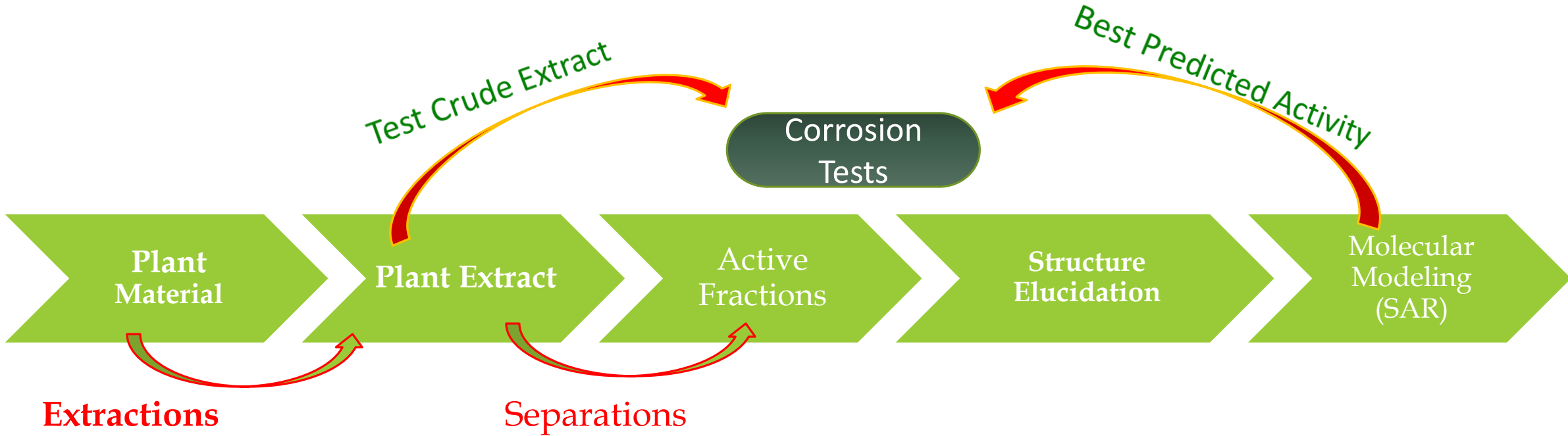


*Oguzie et al., J. Mater. Sci*



# OUR APPROACH

Combined experimental & computational approach



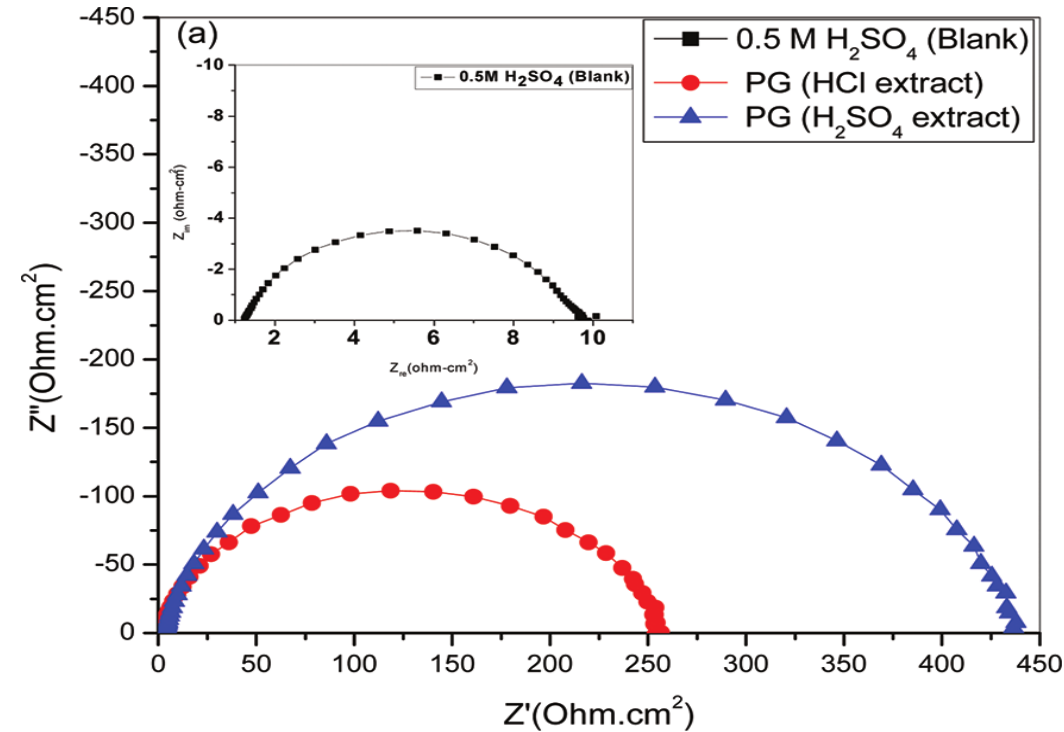
**Experimental Techniques**  
Potentiodynamic polarization  
Impedance spectroscopy  
SEM, AFM, FTIR, XRD, GC-MS

**Computational Techniques (DFT)**  
Quantum Chemical Computations  
Molecular Dynamics Simulations



# BIOMASS CORROSION INHIBITORS (BCI) IN AGGRESSIVE FLUID ENVIRONMENTS

Biomass extracts were assessed for corrosion inhibiting efficacy on mild steel in aggressive acid environments.



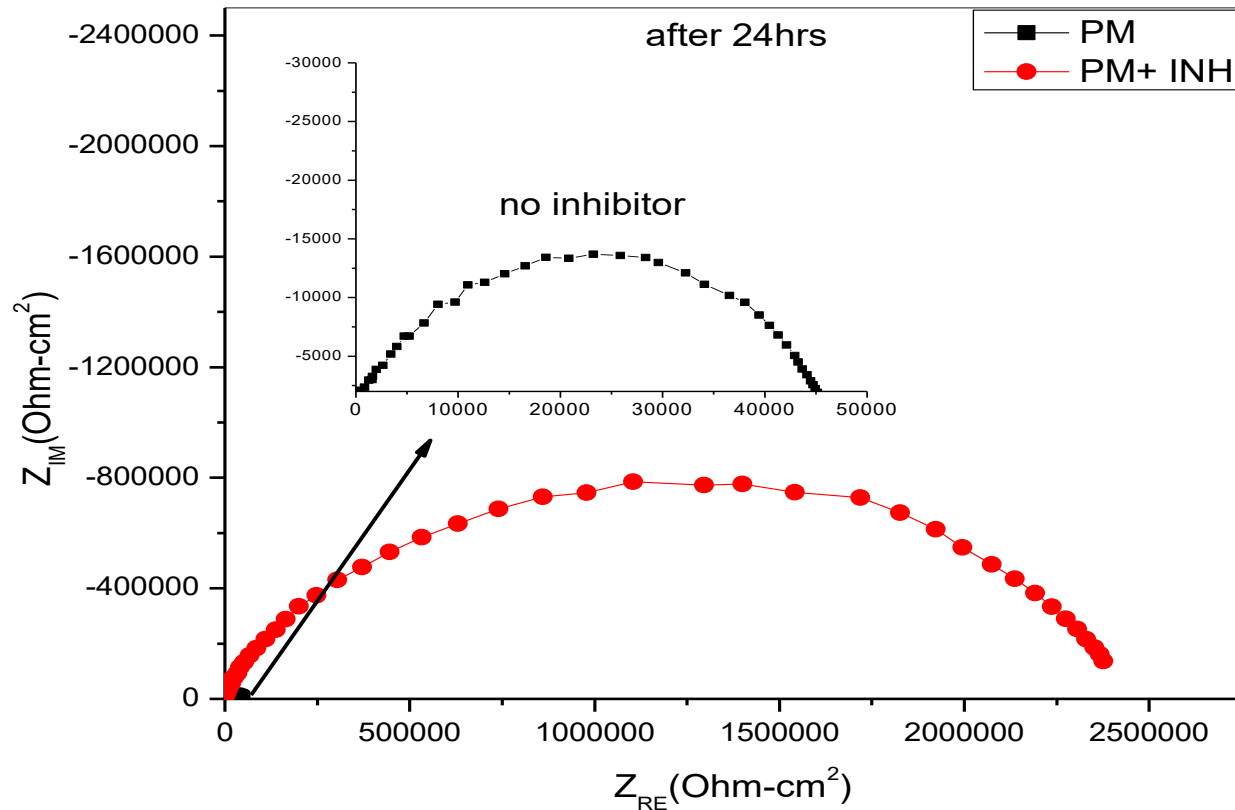
Electrochemical impedance spectra of mild steel in 0.5 M sulphuric acid solution without and with BCI.

Efficiency of Inhibition = 96.1% (HCl extract) and 97.7% (H<sub>2</sub>SO<sub>4</sub> extract)

The BCI have the ability to decrease mild steel corrosion by up to 97% in aggressive acid environments.

# BCIs INCORPORATED AS ANTICORROSION COATING ADDITIVES

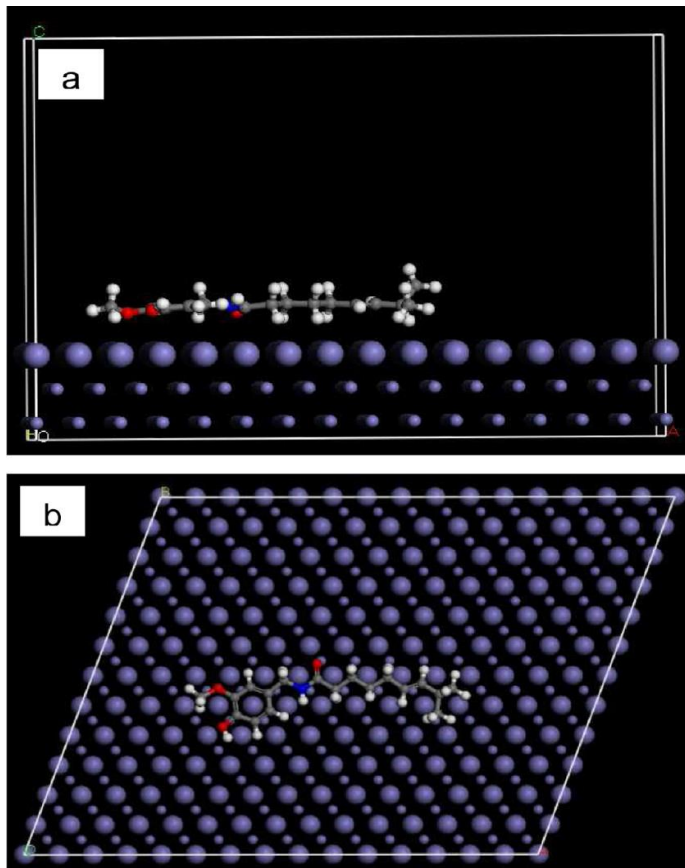
Biomass extracts were also incorporated into anticorrosion primers to further improve corrosion performance.



- Incorporation of BCI greatly improved corrosion resistance
- From 45,000 to 2.5 million Ohm-cm<sup>2</sup>,
- More than one order of magnitude.

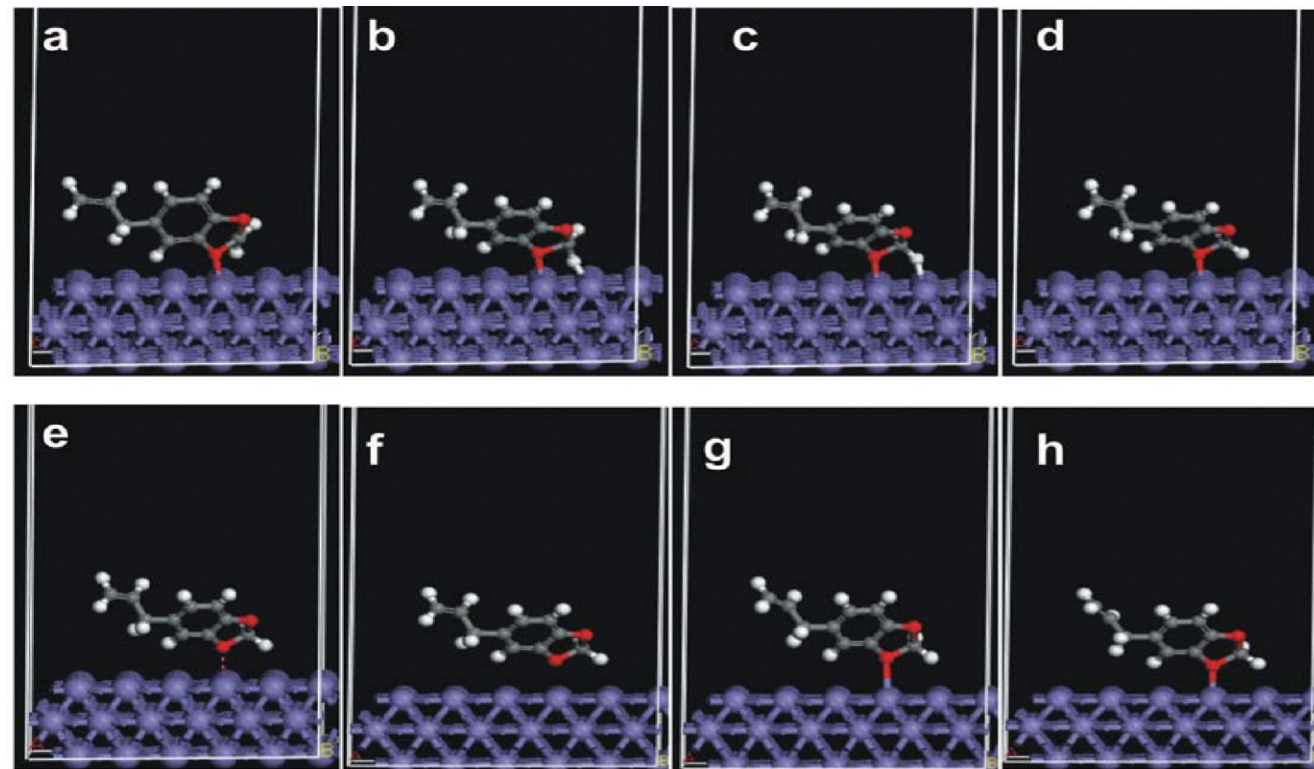
# COMPUTATIONAL MODELLING

Adsorption of biomass extract constituents responsible for the anticorrosion effect



Capsaicin on Fe(110)

*Oguzie et al., ACS Sus. Chem. Engr.*



Changes in adsorption orientation during chemisorption of piperine on Fe (110)

*Oguzie et al., JPC C*

# SUMMARY

---

- ✓ **CORROSION INHIBITING ADDITIVES DEVELOPED FROM NATURAL BIOMASS MATERIALS EFFECTIVELY RETARD METAL CORROSION IN DIFFERENT AGGRESSIVE ENVIRONMENTS**
- ✓ **THE EXTRACTS CAN BE APPLIED AS INHIBITORS IN FLUID ENVIRONMENTS OR AS COATING ADDITIVES WITH ANTICORROSION EFFICIENCY OF OVER 97%.**
- ✓ **MORE AND MORE BIOMASS EXTRACTS SHOULD BE INVESTIGATED FOR ANTICORROSION EFFICACY**



**Thank you for your attention**



[www.emrufuto.com](http://www.emrufuto.com)

# ACKNOWLEDGEMENTS

- TWAS** : For a research grant (2008) and several Fellowships
- CAS**: Funding support
- Chevron**: Funding Support
- 15 Phd Students**
- MSc& BSc Students**
- Collaborators**

•**Prof. Ying Li, Prof. Liu Li, Prof. Bo Zhang, Dr. Shengang Wang**

Institutue of Metal Research, Chinese Academy of Sciences, Shenyang, China

•**Prof. Fuhui Wang**

Northeastern University Shenyang, China

•**Prof. Maja Kliskic, Prof. senka Gudic, Prof. Ladislav Vsarlovic**

University of Split, Teslina, Split, Croatia