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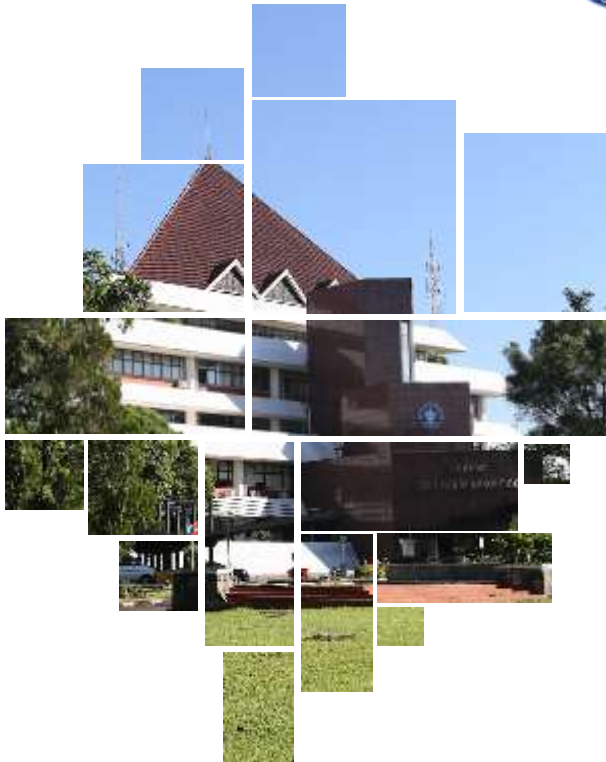
Program Studi Kimia
Departemen Matematika dan Ilmu Pengetahuan Alam
(MIPA)

FORMULASI INHIBITOR KOROSI BERBASIS ZINK-FOSFAT DAN MIKO-DEA PADA PIPA PENDINGIN SEKUNDER REAKTOR SERBA GUNA GERRIT AUGUSTINUS SIWABESSY (RSG-GAS)

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Seminar Hasil
S-2 Kimia, DBR
9 Desember 2024



OUTLINE



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PENDAHULUAN

TINJAUAN PUSTAKA

METODOLOGI

HASIL DAN BAHASAN

KESIMPULAN DAN SARAN

DAFTAR PUSTAKA

PENDAHULUAN

RSG GAS



Sistem Pemipaan

Pipa pendingin reaktor



Pipa pendingin primer

Pipa pendingin sekunder



Reaksi fisi



menimbulkan panas / termal

⇒ perlu sistem pendinginan ⇒ air pendingin



PENDAHULUAN

Pipa pendingin primer (SS)

Pipa pendingin sekunder (CS)



berpotensi terjadi



mempengaruhi umur pipa



- Teknik menghambat laju korosi
- ✓ Pipa → komposisi kimia, pelapisan/
coating, anodizing
 - ✓ Fluida → konsentrasi, pH, laju alir,
inhibitor

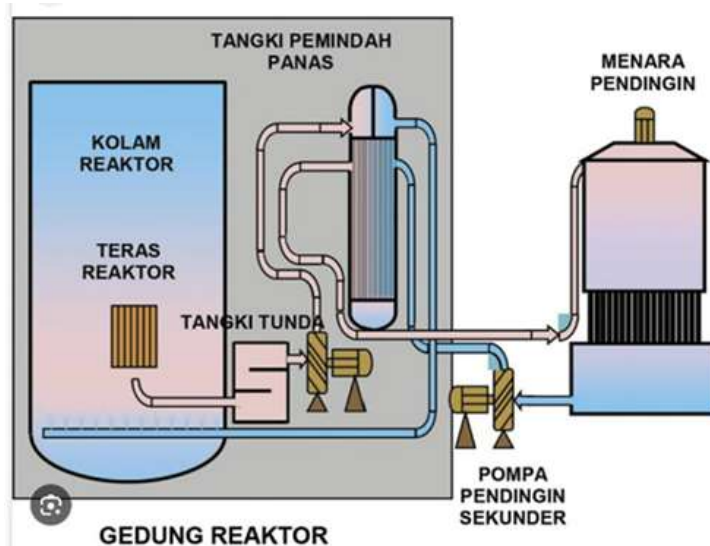


Zink Fosfat - miko.DEA



PENDAHULUAN

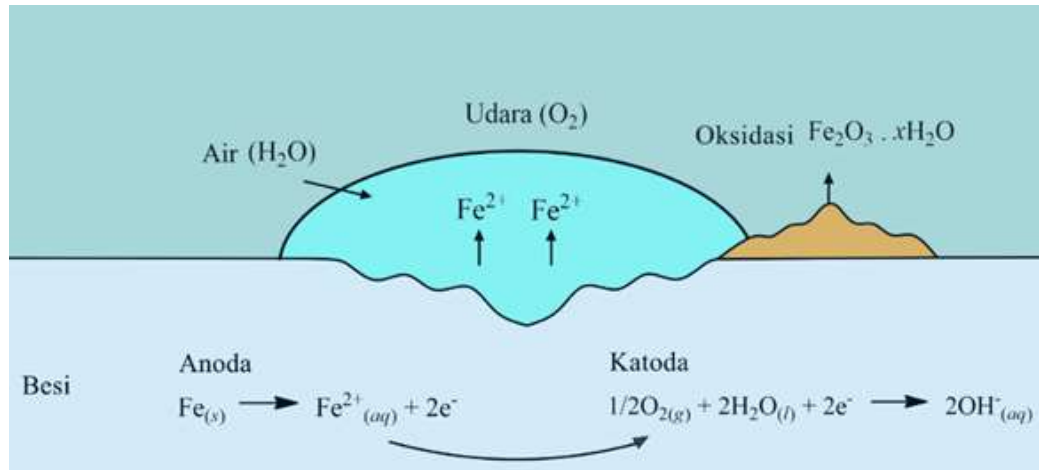
Sistem Pendingin RSG-GAS (Sriyono, 2016)



Sistem pendingin primer
→ air bebas mineral

Sistem pendingin sekunder
→ air tanah

Korosi (Standsbury, 2000)



degradasi /
kerusakan
material akibat
berinteraksi
dengan
lingkungan

PENDAHULUAN

Manfaat



Acuan kebutuhan inhibitor → menghambat laju korosi

Kebaruan (*novelty*)



(2013, Hao *et al.*) Korosi MS → inhibisi $\text{Zn}_3(\text{PO}_4)_2$
(2018, Kusumastuti *et al.*) Korosi CS → inhibitor Dukem
(2018, Ajiriyanto *et al.*) Korosi CS → inhibitor zink fosfat
(2019, Sabzi & Arefinia) Korosi CS → inhibisi Zn^{2+}
(2019, Xu *et al.*) Korosi CS → inhibitor asam tanat
(2019, Sihotang) Korosi Fe → inh. N-Linoleiletanolamida
(2020, Berrissoul *et al.*) Korosi MS → inh. *Lavandula mairei*



PENDAHULUAN

Rumusan masalah



Pengendalian korosi → zat aditif, inhibitor

* inhibitor korosi zink-fosfat → lapisan pasif

* inhibitor miko-DEA → inhibitor organik

→ mengikat agen korosi → CO_2 , Cl^- , SO_4^{2-} , PO_4^{3-} , Ca^{2+}

Tujuan



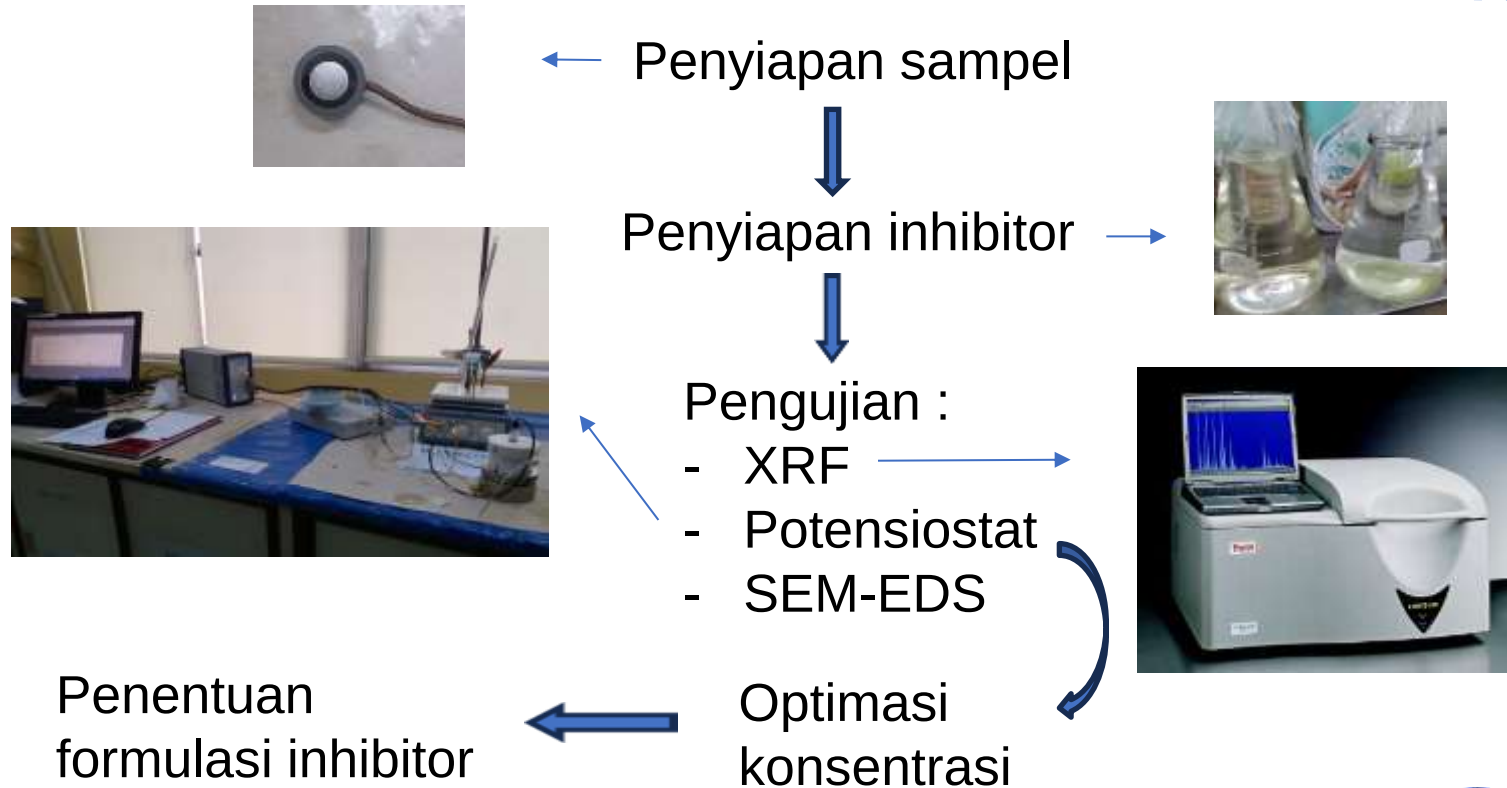
Mendapatkan formula yang efektif

→ kombinasi zink-fosfat dan miko-DEA

→ menghambat korosi

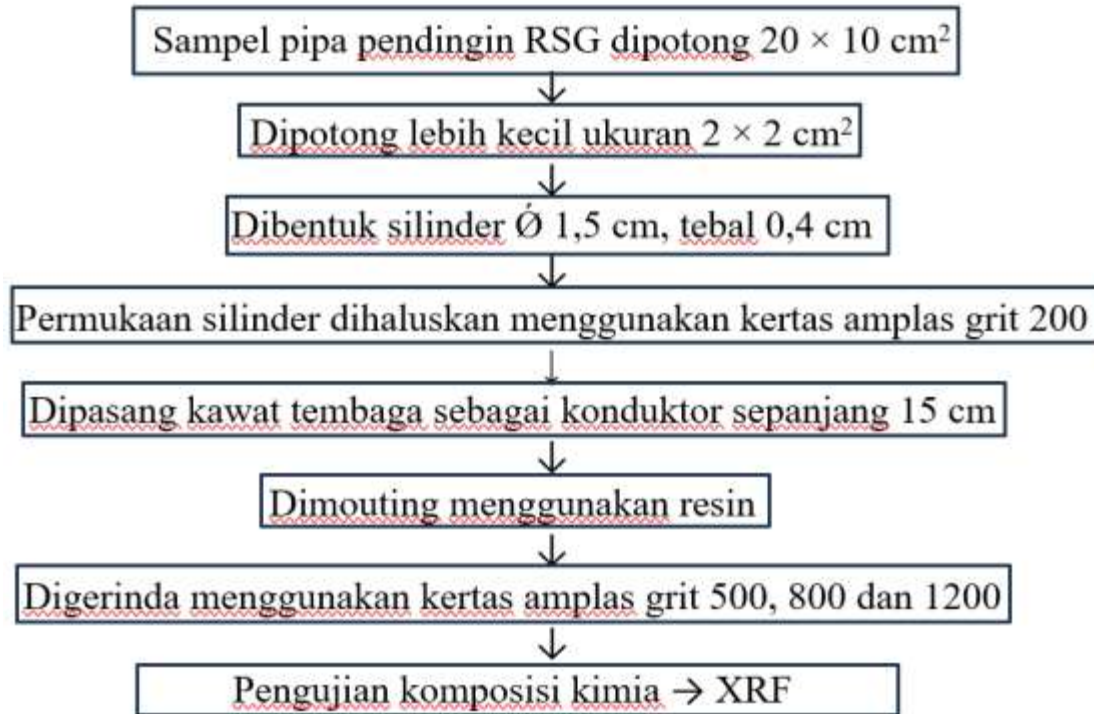


METODOLOGI



A. Penyiapan substrat/sampel baja karbon dan karakterisasi

.....



B. Penyiapan inhibitor dan karakterisasi

Larutan zink-fosfat → RSG

Dilakukan karakterisasi:

- kadar Zn → AAS;
- PO_4^{3-} total → UV-Vis;
- Gugus fungsi → FTIR



Larutan induk konsentrasi 1000 ppm
dipipet sebanyak 5, 7, 10, 15 dan 20 mL



Dimasukkan ke dalam lama labu gondok 200 mL



Ditambahkan air hingga 200 mL

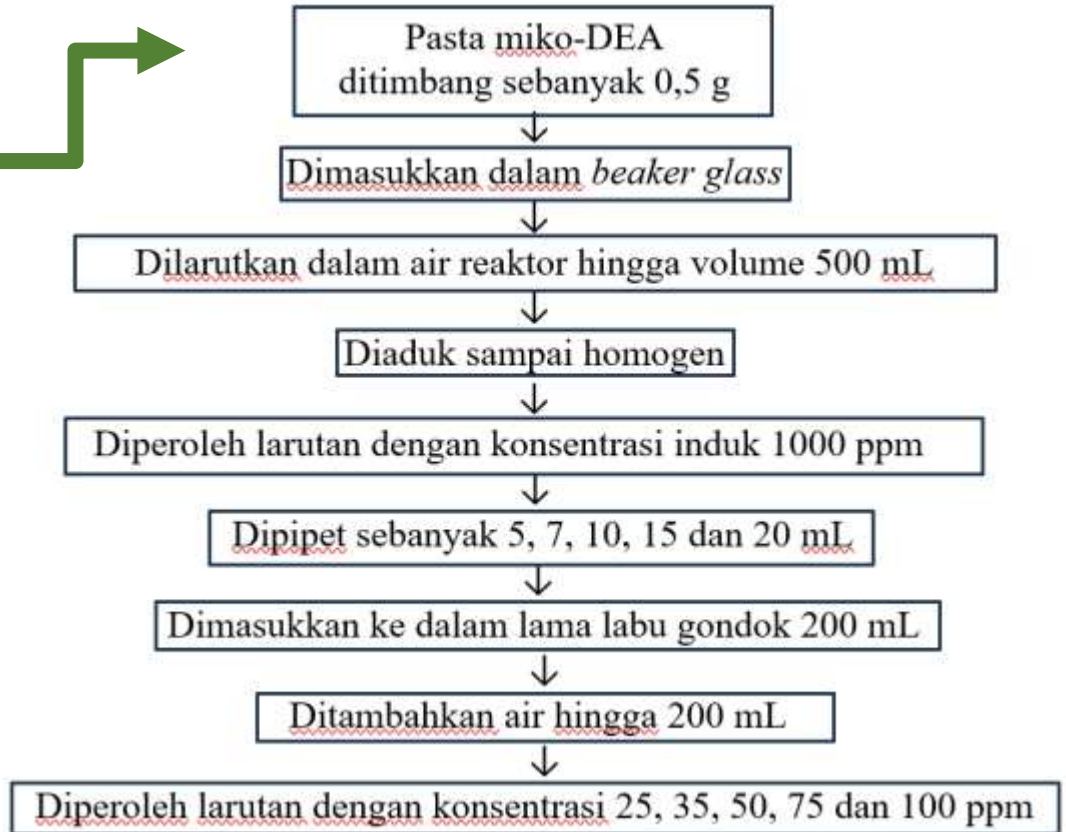


Diperoleh larutan dengan konsentrasi 25, 35, 50, 75 dan 100 ppm

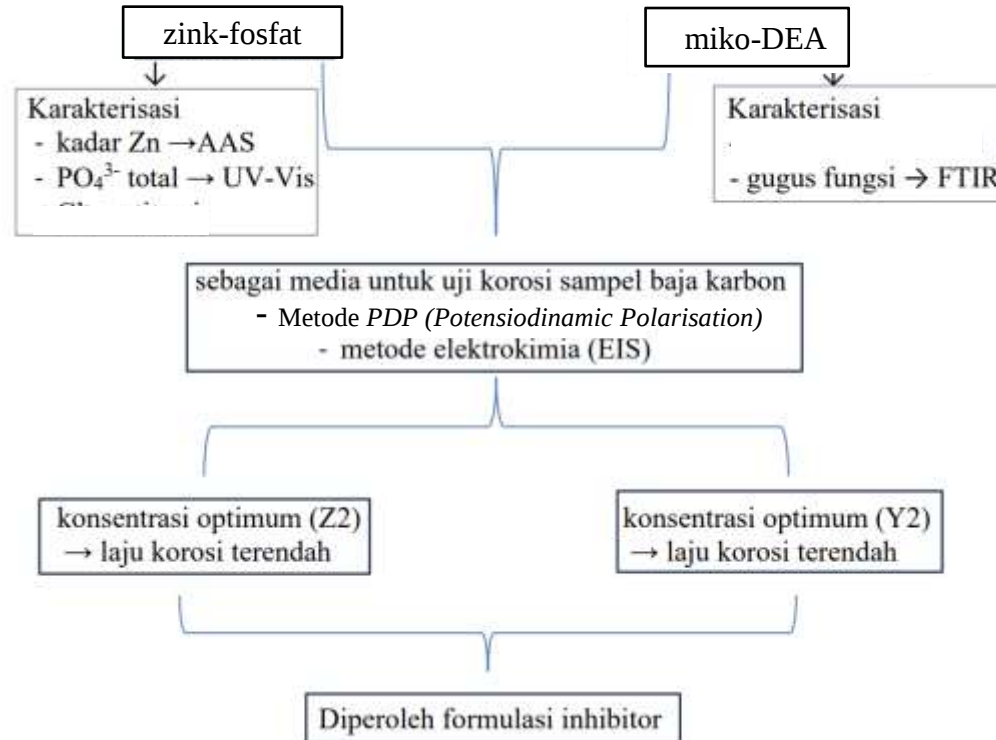
Inhibitor miko-DEA



Dilakukan karakterisasi:
Gugus fungsi → FTIR



C. Uji Kinerja Inhibitor Korosi



D. Analisis data → metode *full factorial*

Data ke-	zink-fosfat	miko-DEA
1	ZF1	MD1
2	ZF1	MD2
3	ZF1	MD3
4	ZF2	MD1
5	ZF2	MD2
6	ZF2	MD3
7	ZF3	MD1
8	ZF3	MD2
9	ZF3	MD3

ZF2 = konsentrasi zink-fosfat (ppm) untuk laju korosi terendah

MD2 = konsentrasi miko-DEA (ppm) untuk laju korosi terendah

ZF1 = konsentrasi zink-fosfat (ppm) yang lebih rendah daripada ZF2

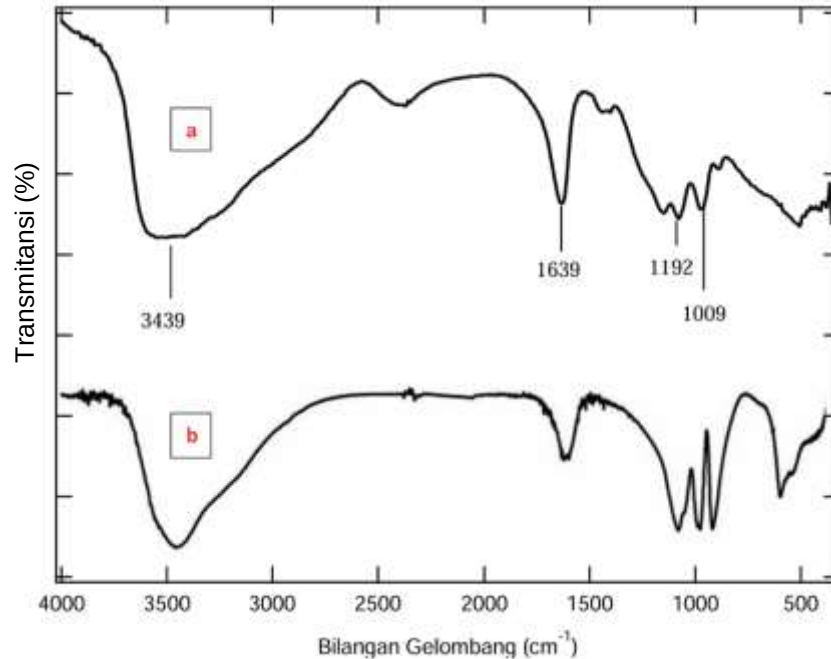
MD1 = konsentrasi miko-DEA (ppm) yang lebih rendah daripada MD2

ZF3 = konsentrasi zink-fosfat (ppm) yang lebih tinggi daripada ZF2

MD3 = konsentrasi miko-DEA (ppm) yang lebih tinggi daripada MD2



HASIL DAN BAHASAN



Spektrum Zink Fosfat → (a) Pengukuran, (b) Referensi^(*)

^(*) Jung, 2009

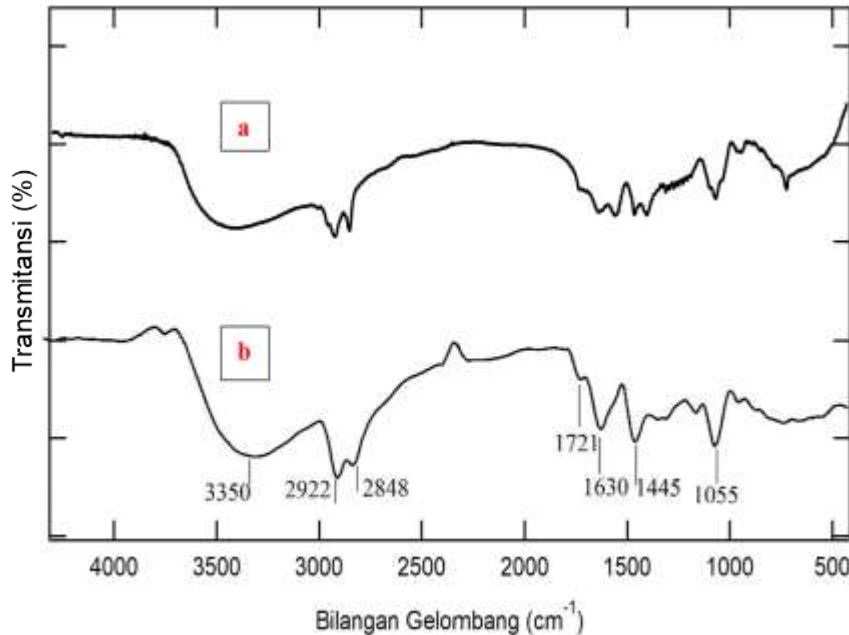
Karakterisasi Inhibitor Zink Fosfat → FTIR

Bilangan gelombang 3439/cm
(daerah spektrum 4000-2500/cm)
→ gugus OH

Bilangan gelombang 1639/cm
(daerah spektrum 2000-1500/cm)
→ ikatan rangkap C=O

Bilangan gelombang 1192 dan 1009/cm
(daerah spektrum 400-1500/cm)
→ finger print spektrum PO₄³⁻

HASIL DAN BAHASAN



Karakterisasi Inhibitor miko.DEA → FTIR

- Bilangan gelombang 3350/ cm → gugus (-OH)
- Bilangan gelombang 2922 dan 2848/ cm → gugus CH alifatik.
- Bilangan gelombang 1445/ cm → gugus CH bending.
- Bilangan gelombang 1055/ cm → gugus CN bending
- Bilangan gelombang 1630/ cm → gugus karbonil (C=O) amida
- Bilangan gelombang 1721/ cm → asam lemak karboksilat

Spektrum miko.DEA → (a) Pengukuran, (b) Referensi(*)

(*) Ningrum, 2022

HASIL DAN BAHASAN

Karakterisasi Substrat → Carbon-Sulfur Analyzer, XRF

Unsur	C	Si	Ti	Mn	Cr
Konsentrasi (%)	0,126	0,183	0,051	0,234	0,050

Karakterisasi Inhibitor Zink Fosfat → AAS, UV-Vis

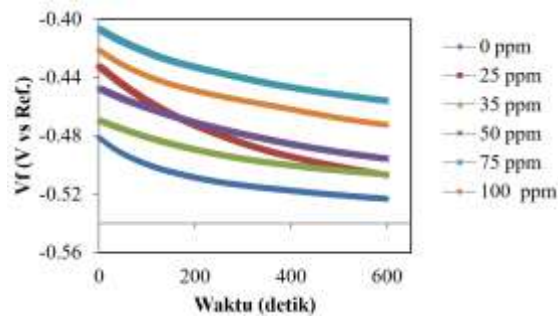
Unsur	Zn	PO ₄ ³⁻
Konsentrasi (%)	3,77	8,65



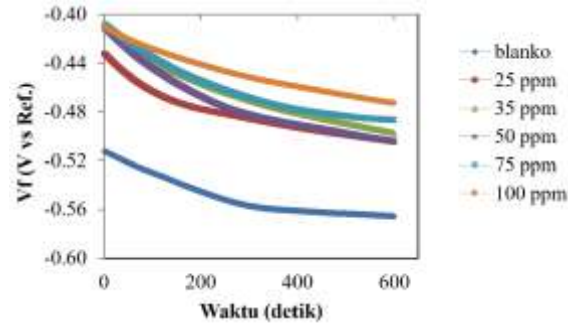
HASIL DAN BAHASAN

A. Uji Korosi

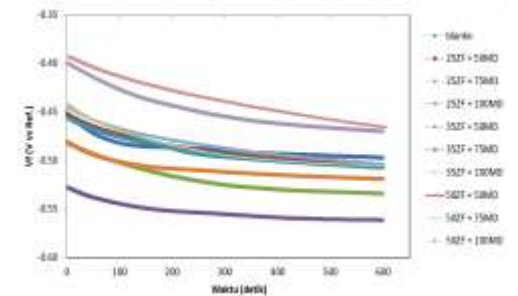
A.1. Open Circuit Potential (OCP)



(a) Zink-Fosfat



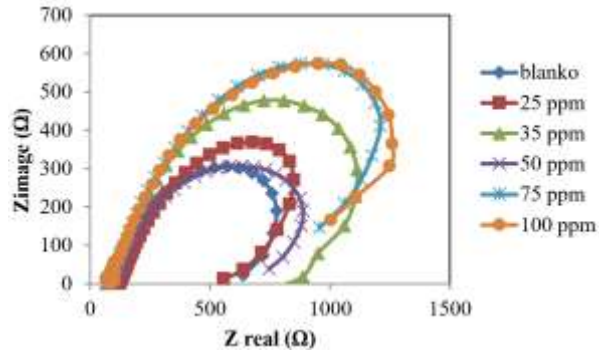
(b) Miko-DEA



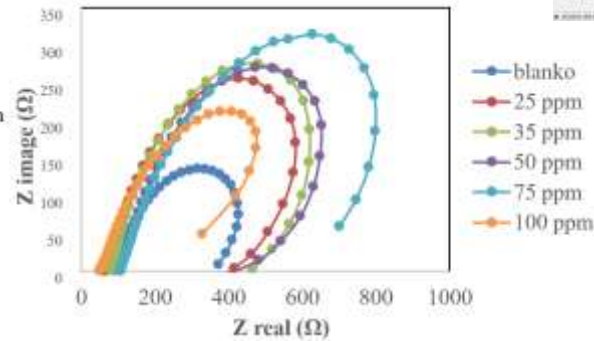
(c) Zink-Fosfat + Miko-DEA

HASIL DAN BAHASAN

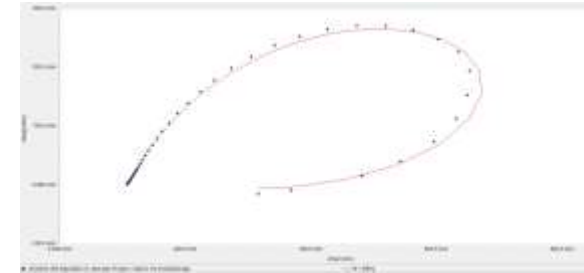
A.2. Electrochemical Impedance Spectrometer (EIS)



(a) Zink-Fosfat



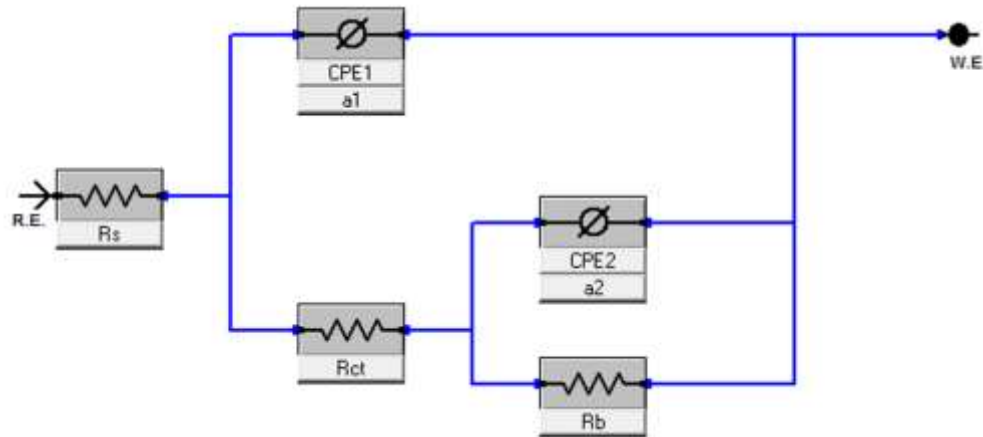
(b) Miko-DEA



(c) Zink-Fosfat + Miko-DEA

HASIL DAN BAHASAN

Fitting EIS → Rangkaian listrik ekivalen



Komponen Listrik :

1. R_s → tahanan larutan
2. R_{ct} → tahanan lapisan
3. R_b → tahanan *barrier*
4. CPE → *Constant Phase Element*

Data EIS

Konsentrasi inhibitor (ppm)	R_s (Ω)	R_{ct} (Ω)	R_b (Ω)	CPE1	CPE2
0 (blanko)	83,86	73,02	691,5	0,786	0,784
25	122,6	134,10	563,0	0,843	0,918
35	75,55	683,00	846,1	0,694	0,643
50	90,35	66,75	803,3	0,726	0,735
75	67,85	67,83	920,0	0,628	0,620
100	133,3	175,0	750,0	0,719	0,619

(a) Zink Fosfat

Konsentrasi inhibitor (ppm)	R_s (Ω)	R_{ct} (Ω)	R_b (Ω)	CPE1	CPE2
0 (blanko)	105,1	563,4	161,6	$1,8 \times 10^{-3}$	$3,9 \times 10^{-4}$
25	90,87	334,5	167,3	$2,6 \times 10^{-3}$	$1,7 \times 10^{-6}$
35	64,81	295,8	460,2	$1,7 \times 10^{-3}$	$1,6 \times 10^{-6}$
50	81,47	230,5	376,5	$9,0 \times 10^{-4}$	$1,1 \times 10^{-3}$
75	106,70	212,1	808,8	$1,4 \times 10^{-3}$	$9,2 \times 10^{-2}$
100	50,72	437,2	601,0	$3,0 \times 10^{-3}$	$2,4 \times 10^{-7}$

(b) Miko.DEA

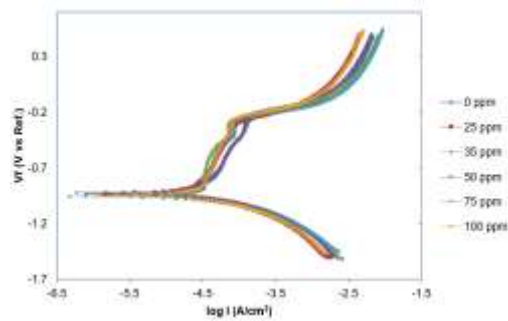
Konsentrasi zink fosfat (ppm)	Konsentrasi miko.DEA (ppm)	R_s (Ω)	R_{ct} (Ω)	R_b (Ω)	CPE1	CPE2
0	0	87,7	47,2	560,4	$1,9 \times 10^{-3}$	$4,4 \times 10^{-4}$
25	50	64,3	659,4	244,4	$1,4 \times 10^{-3}$	$2,8 \times 10^{-4}$
25	75	60,6	371,6	563,1	$1,1 \times 10^{-3}$	$8,2 \times 10^{-4}$
25	100	55,5	50,1	2176,0	$2,8 \times 10^{-4}$	$5,8 \times 10^{-4}$
35	50	59,6	47,8	624,7	$3,7 \times 10^{-4}$	$1,1 \times 10^{-3}$
35	75	108,2	1287,0	108,9	$6,7 \times 10^{-1}$	$1,0 \times 10^{-1}$
35	100	101,7	36,9	1045,0	$1,4 \times 10^{-4}$	$1,1 \times 10^{-3}$
50	50	91,2	391,2	1266,0	$7,7 \times 10^{-4}$	$1,3 \times 10^{-4}$
50	75	109,4	55,6	1015,0	$5,9 \times 10^{-4}$	$1,1 \times 10^{-3}$
50	100	38,9	85,6	1191,0	$1,3 \times 10^{-4}$	$3,7 \times 10^{-4}$

(c) Zink Fosfat + Miko.DEA

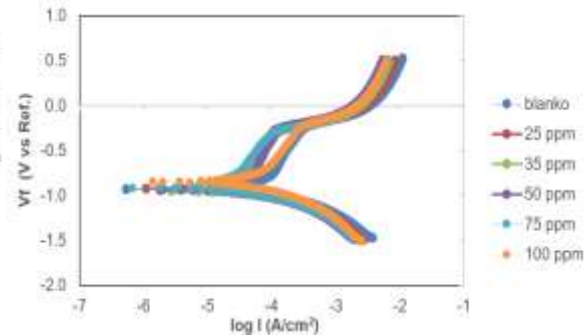


HASIL DAN BAHASAN

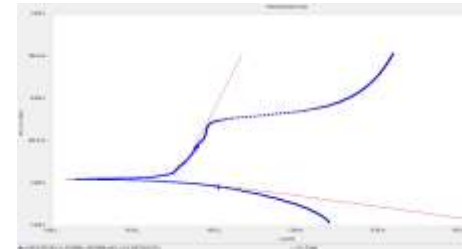
A.3. Potensidynamic Polarization (PDP)



(a) Zink-Fosfat



(b) Miko-DEA



(c) Zink-Fosfat + Miko-DEA

Data PDP

Konsentrasi inhibitor (ppm)	I corr ($\mu\text{A}/\text{cm}^2$)	Laju Korosi (mpy)	Efisiensi Inhibitor (%)
0	46,60	21,01	-
25	31,00	13,95	33,48
35	26,00	11,70	44,21
50	35,10	15,82	24,68
75	31,90	14,36	31,55
100	39,10	17,62	16,09

(a) Zink Fosfat

Konsentrasi inhibitor (ppm)	I corr ($\mu\text{A}/\text{cm}^2$)	Laju Korosi (mpy)	Efisiensi Inhibitor (%)
0	42,41	28,12	-
25	27,27	18,08	35,70
35	26,93	17,86	36,49
50	25,93	17,19	38,87
75	14,46	9,59	65,90
100	35,55	23,57	16,18

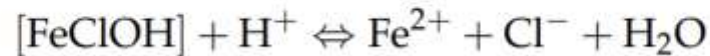
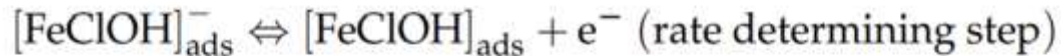
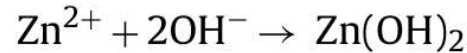
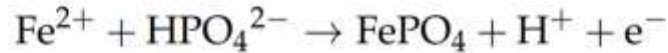
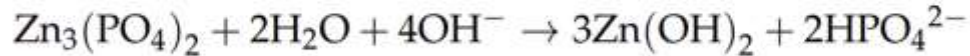
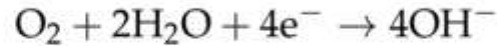
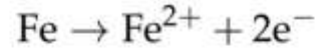
(b) Miko.DEA

Konsentrasi zink fosfat (ppm)	Konsentrasi miko.DEA (ppm)	I corr ($\mu\text{A}/\text{cm}^2$)	Laju Korosi (mpy)	Efisiensi Inhibitor (%)
0	0	42,80	28,12	-
25	50	22,68	14,90	47,01
25	75	19,98	13,13	53,31
25	100	24,54	16,12	42,67
35	50	27,70	18,52	35,28
35	75	24,37	16,01	43,07
35	100	27,50	18,07	35,74
50	50	17,23	11,32	59,74
50	75	16,09	10,57	62,41
50	100	23,30	15,95	43,28

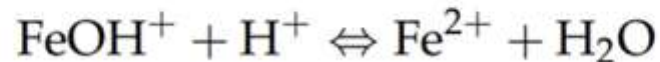
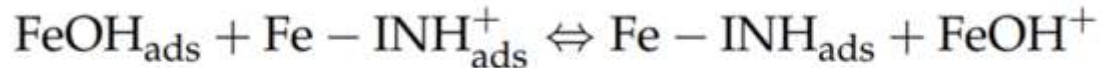
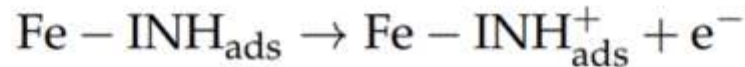
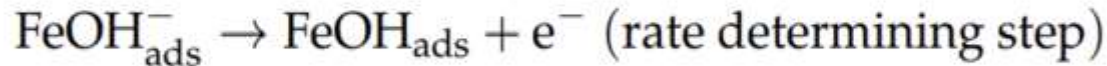
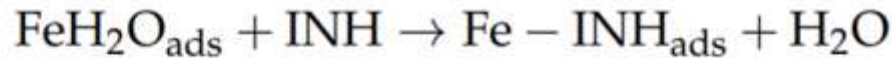
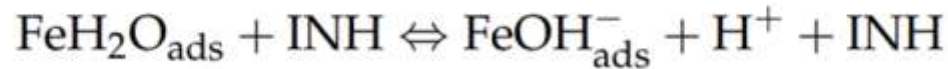
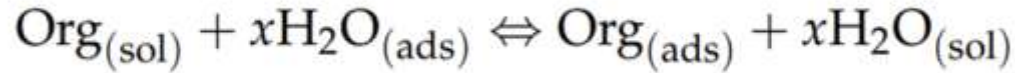
(c) Zink Fosfat + Miko.DEA



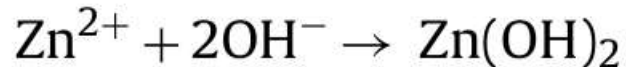
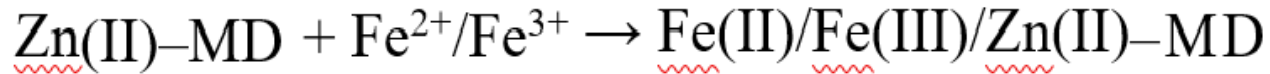
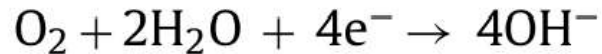
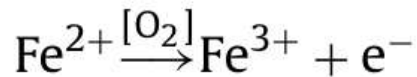
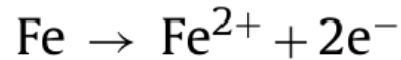
Mekanisme Reaksi Inhibitor Zink-Fosfat (Wan, 2017)



Mekanisme Reaksi Miko-DEA (Chen, 2022)

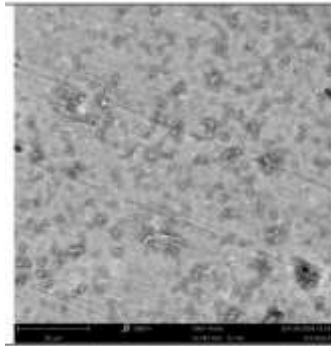


Mekanisme Reaksi ZP + MD (Prabakaran 2013)



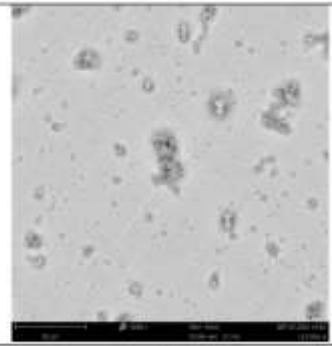
HASIL DAN BAHASAN

B. Morfologi Permukaan → SEM, EDS



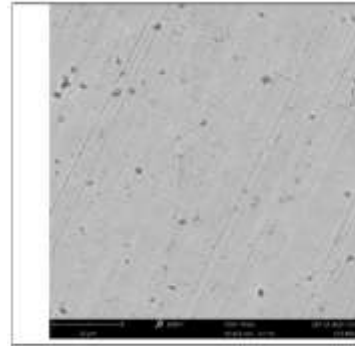
(a)

NaCl 0,1%



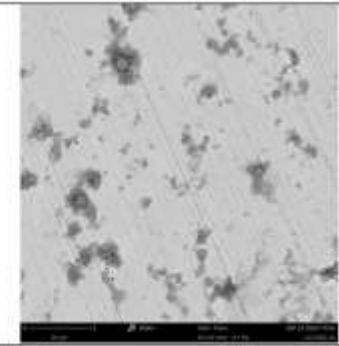
(b)

ZF



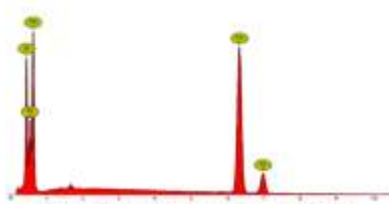
(c)

MD

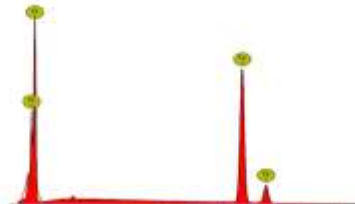


(d)

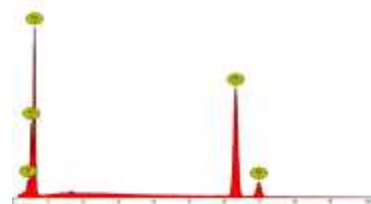
(ZF+MD)



Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
26	Fe	Iron	68.61	88.41
8	O	Oxygen	31.39	11.59



Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
26	Fe	Iron	100.00	100.00



Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
26	Fe	Iron	94.10	98.23
8	O	Oxygen	5.90	1.77



Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
26	Fe	Iron	84.95	95.44
8	O	Oxygen	11.48	3.70
6	C	Carbon	3.57	0.86

KESIMPULAN

- Inhibitor miko.DEA mampu menurunkan laju korosi LCS dalam larutan NaCl 0,1% dan meningkatkan efisiensi inhibitor.
- Kombinasi zink-fosfat:miko-DEA dengan perbandingan 50:75 ppm menurunkan laju korosi dari 28,12 mpy menjadi 10,57 mpy.
- Efisiensi inhibitor meningkat dari 44,21% menjadi 62,41%.



PUSTAKA

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TERIMA KASIH