

**LAMPIRAN A**  
**PERHITUNGAN**

## Lampiran A. Perhitungan

### A.1 Volume MDI

- Massa Poliuretan

$$\text{Massa Poliuretan} = \text{Volume Poliuretan} \times \text{Massa Jenis Poliuretan}$$

$$\text{Massa Poliuretan} = 100 \text{ ml} \times 1,45 \text{ gram/ml}$$

$$\text{Massa Poliuretan} = 145 \text{ gram}$$

- Massa MDI

$$\text{Massa MDI} = \frac{\text{Massa Poliuretan}}{2}$$

$$\text{Massa MDI} = \frac{145 \text{ gram}}{2} = 72,5 \text{ gram}$$

- Volume MDI

$$\text{Volume MDI} = \frac{\text{Massa MDI}}{\text{Densitas MDI}}$$

$$\text{Volume MDI} = \frac{72,5 \text{ gram}}{1,23 \text{ gram/ml}}$$

$$\text{Volume MDI} = 58,9 \text{ ml} \approx 59 \text{ ml}$$

- Massa 10% MDI

$$\text{Massa 10\% MDI} = \text{Massa MDI} \times 10\%$$

$$\text{Massa 10\% MDI} = 72,5 \text{ gram} \times 10\% = 7,25 \text{ gram}$$

- Volume 10% MDI

$$\text{Volume MDI} = \frac{\text{Massa MDI}}{\text{Densitas MDI}}$$

$$\text{Volume MDI} = \frac{7,25 \text{ gram}}{1,23 \text{ gram/ml}}$$

$$\text{Volume MDI} = 5,89 \text{ ml} \approx 5,9 \text{ ml}$$

- Total Massa MDI

$$\text{Total Massa MDI} = \text{Massa MDI} + \text{Massa 10\%}$$

$$\text{MDI Total Massa MDI} = 72,5 \text{ gram} + 7,25 \text{ gram} = 79,75 \text{ gram}$$

- Volume Total MDI

$$\text{Volume MDI} = \frac{\text{Massa MDI}}{\text{Densitas MDI}}$$

$$\text{Volume MDI} = \frac{79,75 \text{ gram}}{1,23 \text{ gram/ml}}$$

$$\text{Volume MDI} = 64,8 \text{ ml} \approx 64 \text{ ml}$$

## A.2 Volume Polioliol

$$\text{Volume Polioliol} = 100 \text{ ml} - \text{volume MDI}$$

$$\text{Volume Polioliol} = 100 \text{ ml} - 59 \text{ ml}$$

$$\text{Volume Polioliol} = 41 \text{ ml}$$

## A.3 Massa Bahan Proses Glikolisis

- Massa LDPE 16 gram

$$\text{➤ Mol LDPE} = \frac{\text{Massa LDPE}}{\text{Berat Molekul LDPE}}$$

$$\text{Mol LDPE} = \frac{16 \text{ gram}}{60.000 \text{ gram/mol}}$$

$$\text{Mol LDPE} = 0,00027 \text{ mol}$$

- Zink Asetat

$$\text{Zink Asetat} = 0,5\% \text{ LDPE}$$

$$\text{Zink Asetat} = 0,5\% \times 16 \text{ gram}$$

$$\text{Zink Asetat} = 0,08 \text{ gram}$$

- Mol DEG (Mol LDPE : Mol DEG = 1 : 4)

$$\text{Mol DEG} = 4 \times \text{Mol LDPE}$$

$$\text{Mol DEG} = 4 \times 0,00027 \text{ mol}$$

$$\text{Mol DEG} = 0,000108 \text{ mol}$$

- Massa DEG

$$\text{Massa DEG} = \text{Mol DEG} \times \text{Berat Molekul DEG}$$

$$\text{Massa DEG} = 0,000108 \text{ mol} \times 106,12 \text{ gram/mol}$$

$$\text{Massa DEG} = 0,115 \text{ gram}$$

➤ Volume DEG

$$\text{Volume DEG} = \frac{\text{Massa DEG}}{\text{Densitas DEG}}$$

$$\text{Volume DEG} = \frac{0,115 \text{ gram}}{1,118 \text{ gram/mol}}$$

$$\text{Volume DEG} = 0,103 \text{ ml}$$

• Massa LLDPE 16 gram

➤  $\text{Mol LLDPE} = \frac{\text{Massa LLDPE}}{\text{Berat Molekul LLDPE}}$

$$\text{Mol LLDPE} = \frac{16 \text{ gram}}{300.000 \text{ gram/mol}}$$

$$\text{Mol LLDPE} = 0,000053 \text{ mol}$$

➤ Zink Asetat

$$\text{Zink Asetat} = 0,5\% \text{ LLDPE}$$

$$\text{Zink Asetat} = 0,5\% \times 16 \text{ gram}$$

$$\text{Zink Asetat} = 0,08 \text{ gram}$$

➤ Mol DEG (Mol LLDPE : Mol DEG = 1 : 4)

$$\text{Mol DEG} = 4 \times \text{Mol LLDPE}$$

$$\text{Mol DEG} = 4 \times 0,000053 \text{ mol}$$

$$\text{Mol DEG} = 0,0002132 \text{ mol}$$

➤ Massa DEG

$$\text{Massa DEG} = \text{Mol DEG} \times \text{Berat Molekul DEG}$$

$$\text{Massa DEG} = 0,0002132 \text{ mol} \times 106,12 \text{ gram/mol}$$

$$\text{Massa DEG} = 0,0226 \text{ gram}$$

➤ Volume DEG

$$\text{Volume DEG} = \frac{\text{Massa DEG}}{\text{Berat Molekul DEG}}$$

$$\text{Volume DEG} = \frac{0,0226 \text{ gram}}{1,118 \text{ gram/mol}}$$

$$\text{Volume DEG} = 0,0202 \text{ ml}$$

- Massa HDPE 16 gram

➤  $\text{Mol HDPE} = \frac{\text{Massa HDPE}}{\text{Berat Molekul HDPE}}$

$$\text{Mol HDPE} = \frac{16 \text{ gram}}{200 \text{ gram/mol}}$$

$$\text{Mol HDPE} = 0,08 \text{ mol}$$

- Zink Asetat

$$\text{Zink Asetat} = 0,5\% \text{ HDPE}$$

$$\text{Zink Asetat} = 0,5\% \times 16 \text{ gram}$$

$$\text{Zink Asetat} = 0,08 \text{ gram}$$

- Mol DEG (Mol HDPE : Mol DEG = 1 : 4)

$$\text{Mol DEG} = 4 \times \text{Mol HDPE}$$

$$\text{Mol DEG} = 4 \times 0,08 \text{ mol}$$

$$\text{Mol DEG} = 0,32 \text{ mol}$$

- Massa DEG

$$\text{Massa DEG} = \text{Mol DEG} \times \text{Berat Molekul DEG}$$

$$\text{Massa DEG} = 0,32 \text{ mol} \times 106,12 \text{ gram/mol}$$

$$\text{Massa DEG} = 33,96 \text{ gram}$$

- Volume DEG

$$\text{Volume DEG} = \frac{\text{Massa DEG}}{\text{Berat Molekul DEG}}$$

$$\text{Volume DEG} = \frac{33,96 \text{ gram}}{1,118 \text{ gram/mol}}$$

$$\text{Volume DEG} = 30,376 \text{ ml}$$

- Massa PP 16 gram

$$\text{➤ Mol PP} = \frac{\text{Massa PP}}{\text{Berat Molekul PP}}$$

$$\text{Mol PP} = \frac{16 \text{ gram}}{525.000 \text{ gram/mol}}$$

$$\text{Mol PP} = 0,0000305 \text{ mol}$$

➤ Zink Asetat

$$\text{Zink Asetat} = 0,5\% \text{ PP}$$

$$\text{Zink Asetat} = 0,5\% \times 16 \text{ gram}$$

$$\text{Zink Asetat} = 0,08 \text{ gram}$$

➤ Mol DEG (Mol PP : Mol DEG = 1 : 4)

$$\text{Mol DEG} = 4 \times \text{Mol PP}$$

$$\text{Mol DEG} = 4 \times 0,0000305 \text{ mol}$$

$$\text{Mol DEG} = 0,000122 \text{ mol}$$

➤ Massa DEG

$$\text{Massa DEG} = \text{Mol DEG} \times \text{Berat Molekul DEG}$$

$$\text{Massa DEG} = 0,000122 \text{ mol} \times 106,12 \text{ gram/mol}$$

$$\text{Massa DEG} = 0,0129 \text{ gram}$$

➤ Volume DEG

$$\text{Volume DEG} = \frac{\text{Massa DEG}}{\text{Berat Molekul DEG}}$$

$$\text{Volume DEG} = \frac{0,0129 \text{ gram}}{1,118 \text{ gram/mol}}$$

$$\text{Volume DEG} = 0,0115 \text{ ml}$$

• Massa PET 40 gram

$$\text{➤ Mol PET} = \frac{\text{Massa PET}}{\text{Berat Molekul PET}}$$

$$\text{Mol PET} = \frac{16 \text{ gram}}{192 \text{ gram/mol}}$$

$$\text{Mol PET} = 0,083 \text{ mol}$$

- Zink Asetat  
 Zink Asetat = 0,5% PET  
 Zink Asetat = 0,5% x 40 gram  
 Zink Asetat = 0,2 gram
  
- Mol DEG (Mol PET : Mol DEG = 1 : 4)  
 Mol DEG = 4 x Mol PET  
 Mol DEG = 4 x 0,083 mol  
 Mol DEG = 0,332 mol
  
- Massa DEG  
 Massa DEG = Mol DEG x Berat Molekul DEG  
 Massa DEG = 0,332 mol x 106,12 gram/mol  
 Massa DEG = 35,232 gram
  
- Volume DEG  

$$\text{Volume DEG} = \frac{\text{Massa DEG}}{\text{Berat Molekul DEG}}$$

$$\text{Volume DEG} = \frac{35,232 \text{ gram}}{1,118 \text{ gram/mol}}$$
 Volume DEG = 31,513 ml

#### A.4 Massa Aquades dan Surfaktan

- Sampel PUR-11
  - Massa poliol PET = 10,24 g  
 Massa poliol HDPE = 10,24 x 3% = 0,31 g  
 Massa poliol PET+HDPE = 10,55 g
  
  - Massa Aquades  
 Massa Aquades = 1,32% x massa poliol  
 Massa Aquades = 1,32% x 10,55 g  
 Massa Aquades = 1,14 g

- Massa Surfaktan
  - Massa Surfaktan = 4% x massa poliol
  - Massa Surfaktan = 4% x 10,55 g
  - Massa Surfaktan = 0,42 g
  
- Sampel PUR-21
  - Massa poliol PET = 10,78 g
    - Massa poliol LDPE = 10,78 x 3,5% = 0,38 g
    - Massa poliol PET+LDPE = 11,16 g
  
  - Massa Aquades
    - Massa Aquades = 4,6% x massa poliol
    - Massa Aquades = 4,6% x 11,16 g
    - Massa Aquades = 0,51 g
  
  - Massa Surfaktan
    - Massa Surfaktan = 3,9% x massa poliol
    - Massa Surfaktan = 3,9% x 11,16 g
    - Massa Surfaktan = 0,44 g
  
- Sampel PUR-22
  - Massa poliol PET = 10,92 g
    - Massa poliol LLDPE = 10,92 x 3,6% = 0,39 g
    - Massa poliol PET+LLDPE = 11,31 g
  
  - Massa Aquades
    - Massa Aquades = 1,5% x massa poliol
    - Massa Aquades = 1,5% x 11,31 g
    - Massa Aquades = 0,17 g
  
  - Massa Surfaktan



$$\text{Massa Surfaktan} = 3,9\% \times \text{massa poliol}$$

$$\text{Massa Surfaktan} = 3,9\% \times 11,31 \text{ g}$$

$$\text{Massa Surfaktan} = 0,44 \text{ g}$$

- Sampel PUR-23

- Massa poliol PET = 10,79 g

$$\text{Massa poliol PP} = 10,79 \times 3,6\% = 0,39 \text{ g}$$

$$\text{Massa poliol PET+PP} = 11,18 \text{ g}$$

- Massa Aquades

$$\text{Massa Aquades} = 1,5\% \times \text{massa poliol}$$

$$\text{Massa Aquades} = 1,5\% \times 11,18 \text{ g}$$

$$\text{Massa Aquades} = 0,17 \text{ g}$$

- Massa Surfaktan

$$\text{Massa Surfaktan} = 3,9\% \times \text{massa poliol}$$

$$\text{Massa Surfaktan} = 3,9\% \times 11,18 \text{ g}$$

$$\text{Massa Surfaktan} = 0,44 \text{ g}$$

- Massa Surfaktan

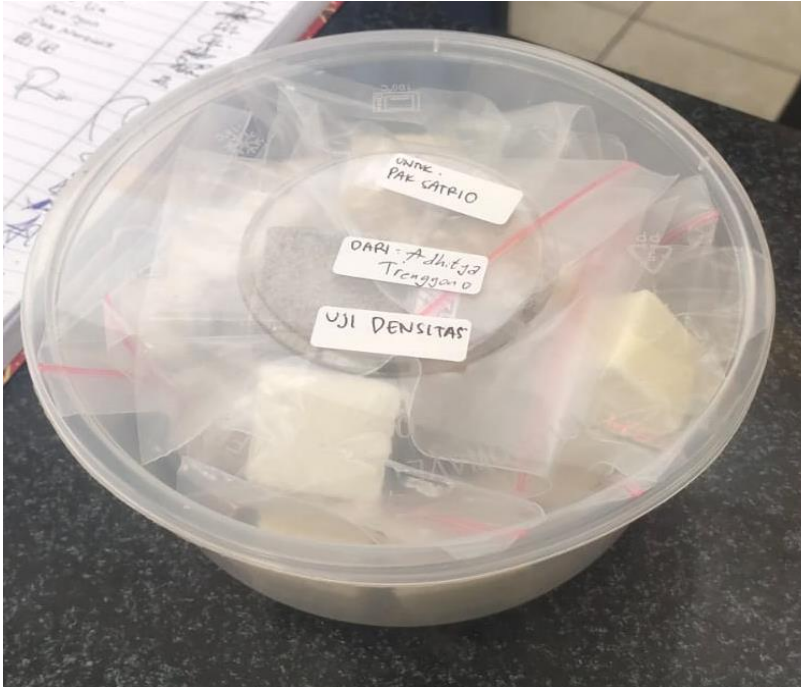
$$\text{Massa Surfaktan} = 3,9\% \times \text{massa poliol}$$

$$\text{Massa Surfaktan} = 3,9\% \times 11,18 \text{ g}$$

$$\text{Massa Surfaktan} = 0,44 \text{ g}$$

**LAMPIRAN B**  
**DATA DAN HASIL PENELITIAN**

## Lampiran B.1. Data Hasil Penelitian



**Gambar B1.** Sampel yang Dikirim Untuk Pengujian



**Gambar B2.** Sampel yang Dihasilkan

## B.2 Data Uji Densitas



### PUSAT RISET METALURGI

Gedung Manajemen 720, Kawasan Sains dan Teknologi, B.J. Habibie  
Setu, Tangerang Selatan, Banten, 15314  
Surel: [prm@brin.go.id](mailto:prm@brin.go.id), Laman: [www.brin.go.id](http://www.brin.go.id)

### LAPORAN PENGUJIAN

Penentuan Nilai Densitas Padatan Non Serbuk

Kode Sampel : Sponge Polymer  
Deskripsi : -  
Tgl. Terima sampel : 06/11/2023  
Tgl. Pengujian : 06/11/2023 - 08/11/2023  
Alat Uji : Density Determination KIT 85 dengan Analytical Balance AS 220.R2

#### Data Hasil Pengujian

Jenis cairan : Aquadest Suhu cairan : 27 °C

Kode Sampel	Pengujian ke-			Nilai densitas (gram/cm <sup>3</sup> )
	x-(1)	x-(2)	x-(3)	
PUR-8	0.071724	0.064255	0.064196	0.066725
PUR-11	0.058900	0.061035	0.059286	0.059740
PUR-21	0.072552	0.073250	0.071283	0.072361
PUR-22	0.082962	0.081213	0.083667	0.082614
PUR-23	0.066638	0.066957	0.067259	0.066951
PUR-7	0.118174	0.107221	0.115970	0.113788
PUR-14	0.067083	0.067249	0.069192	0.067841
PUR-15	0.096901	0.094206	0.097988	0.096365
PUR-17	0.048484	0.045496	0.044001	0.045993
PUR-18	0.052353	0.055226	0.055438	0.054339

\*) Hasil pengujian hanya merepresentasikan kondisi sampel yang diuji.

Dilaksanakan oleh:	Made Subekti Dwijaya, M.T.
Diperiksa oleh:	Made Subekti Dwijaya, M.T.

Tgl. Terbit Laporan: 14/11/2023

Halaman 1/1

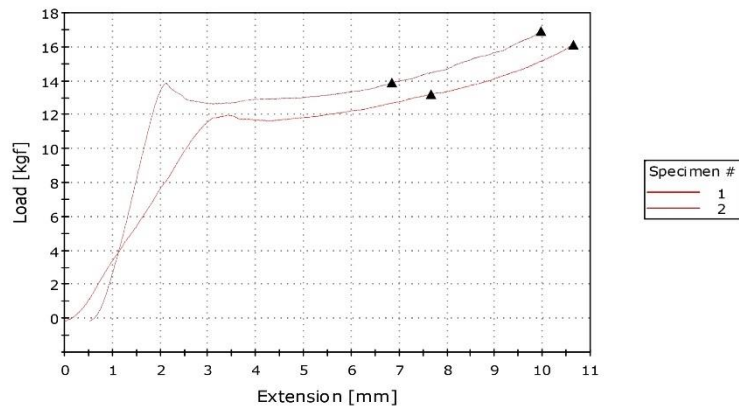
### B.3 Data Uji Kuat Tekan

TEST REPORT



No. Report	073/EXT/JNT/MT/11/2023
Test Method	ASTM D1621
Rate 1	5.00000 mm/min

Specimen 1 to 2



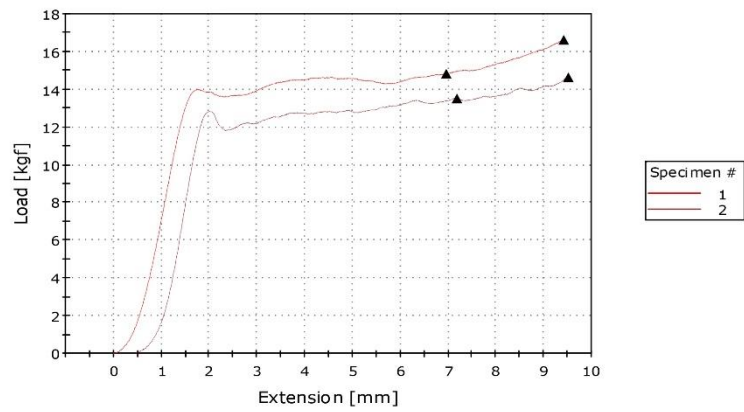
	Description	Width [mm]	Thickness [mm]	Load at yield [N]	Compressive stress at yield [MPa]	Maximum Load [N]	Compressive stress at Maximum Load [MPa]
1	PUR-11 1	23.20	21.44	130.06	0.26	158.07	0.32
2	PUR-11 2	25.14	20.38	142.75	0.28	166.01	0.32

TEST REPORT



No. Report	078/EXT/UNT/MT/11/2023
Test Method	ASTM D1621
Rate 1	5.00000 mm/min

Specimen 1 to 2



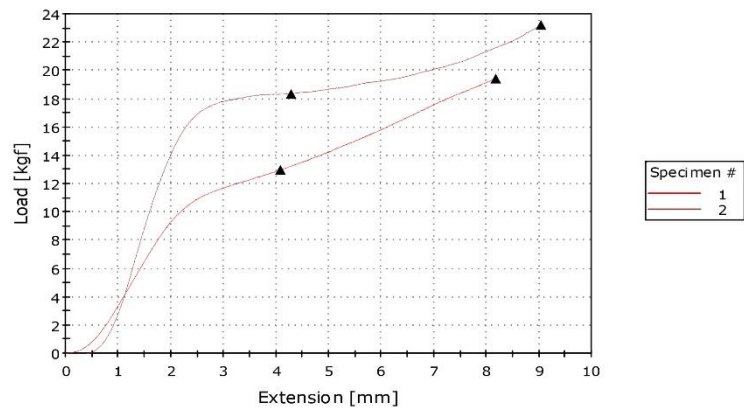
	Description	Width [mm]	Thickness [mm]	Load at yield [N]	Compressive stress at yield [MPa]	Maximum Load [N]	Compressive stress at Maximum Load [MPa]
1	PUR-21 1	24.15	20.85	150.50	0.30	162.93	0.32
2	PUR-21 2	22.86	19.82	135.33	0.30	143.65	0.32

TEST REPORT



No. Report	079/EXT/UNT/MT/11/2023
Test Method	ASTM D1621
Rate 1	5.00000 mm/min

Specimen 1 to 2



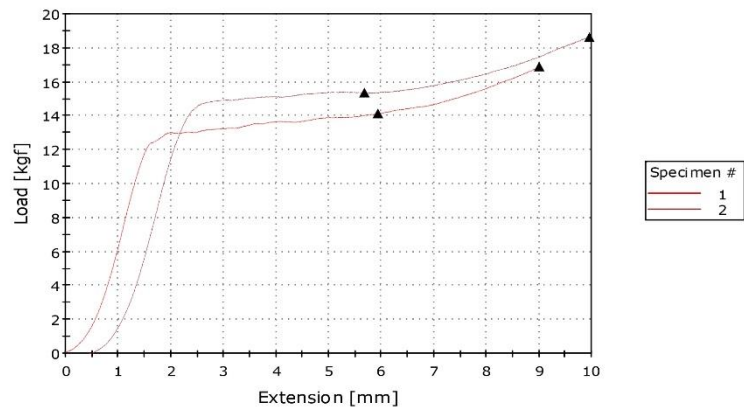
	Description	Width [mm]	Thickness [mm]	Load at yield [N]	Compressive stress at yield [MPa]	Maximum Load [N]	Compressive stress at Maximum Load [MPa]
1	PUR-22 1	21.20	20.20	135.99	0.32	190.49	0.44
2	PUR-22 2	20.53	20.38	185.26	0.44	227.68	0.54

TEST REPORT



No. Report	080/EXT/UNT/MT/11/2023
Test Method	ASTM D1621
Rate 1	5.00000 mm/min

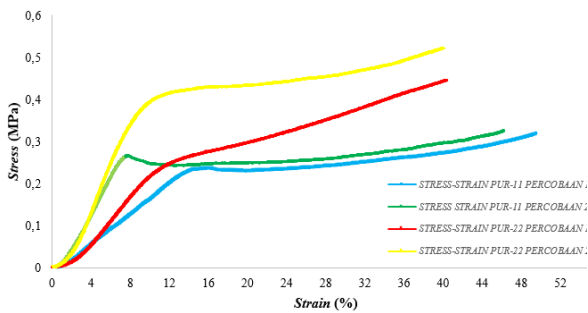
Specimen 1 to 2



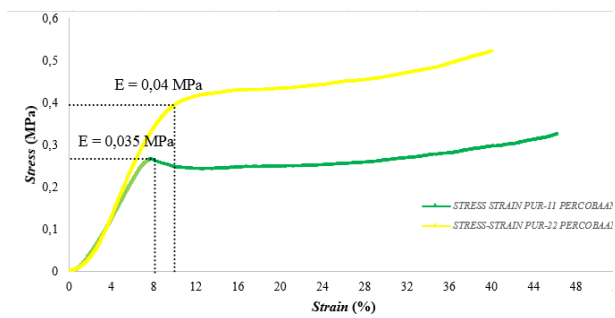
	Description	Width [mm]	Thickness [mm]	Load at yield [N]	Compressive stress at yield [MPa]	Maximum Load [N]	Compressive stress at Maximum Load [MPa]
1	PUR-23 1	22.07	19.39	142.93	0.33	165.65	0.39
2	PUR-23 2	22.61	20.66	154.34	0.33	182.71	0.39



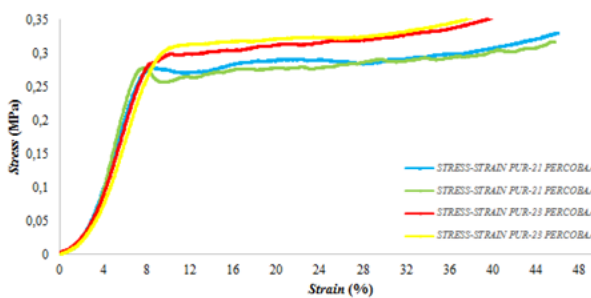
### B.4 Data Kuat Tekan



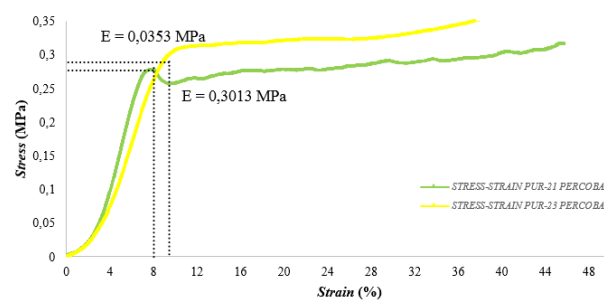
Gambar B.1 Kuat Tekan PUR-11 & PUR-22



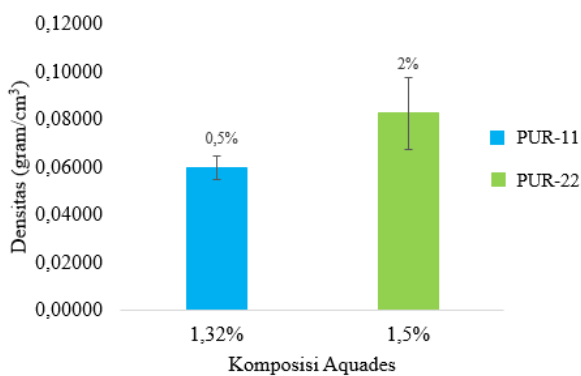
Gambar B.2 Kuat Tekan PUR-11 & PUR-22



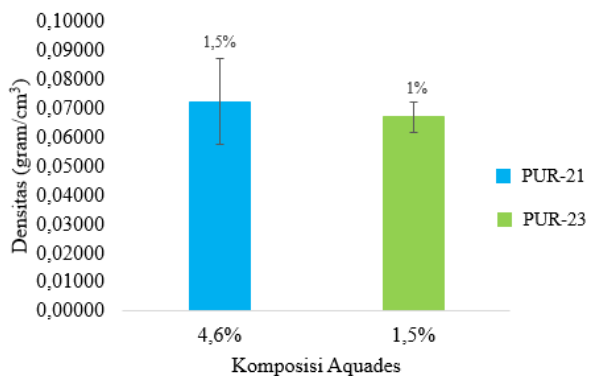
Gambar B.3 Kuat Tekan PUR-21 & 23



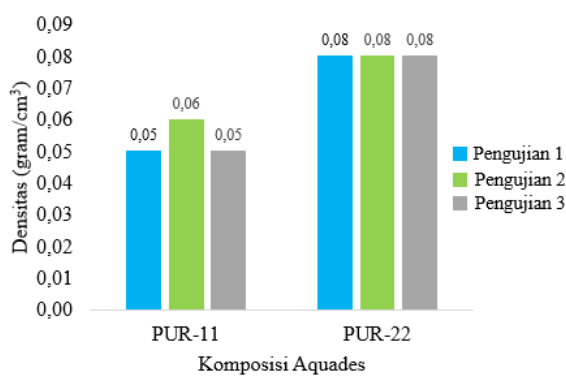
Gambar B.4 Kuat Tekan PUR-21 & 23



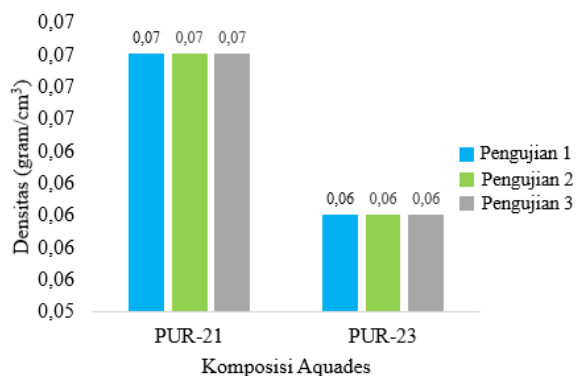
Gambar B.5 Densitas PUR-11 & PUR-22



Gambar B.6 Densitas PUR-21 & PUR-23

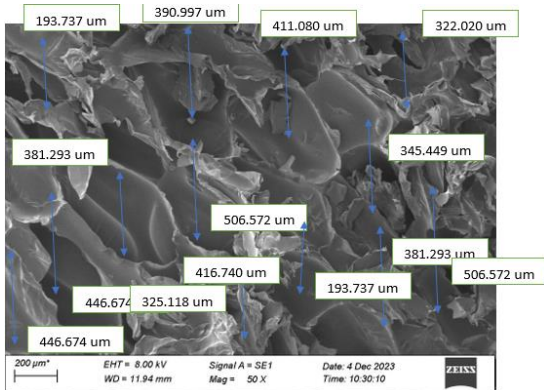


Gambar B.7 Densitas PUR-11 & PUR-22

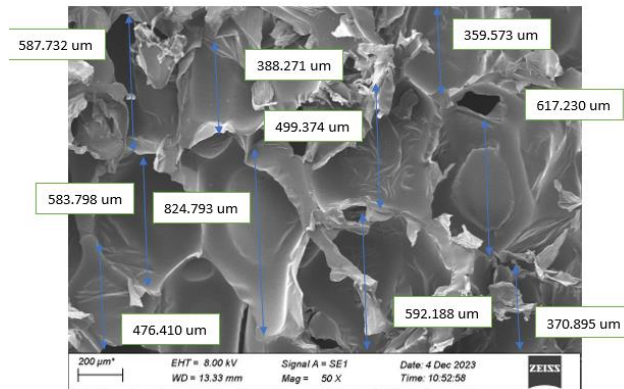


Gambar B.8 Densitas PUR-21 & PUR-23

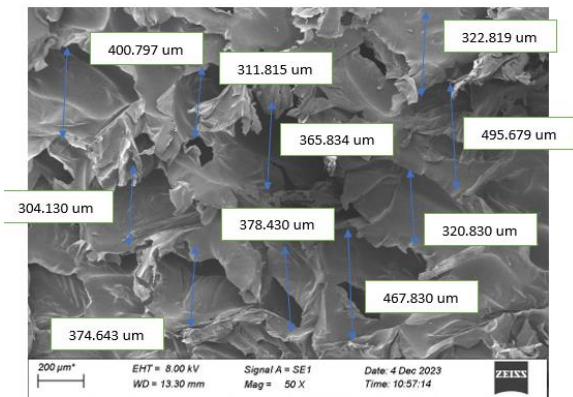
## B.5 Data SEM



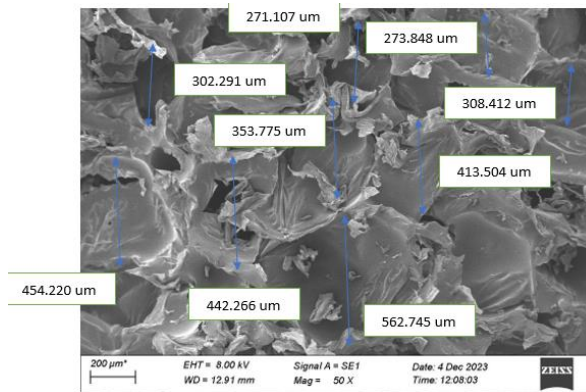
Gambar B.9 SEM PUR-11 Ukuran 50x



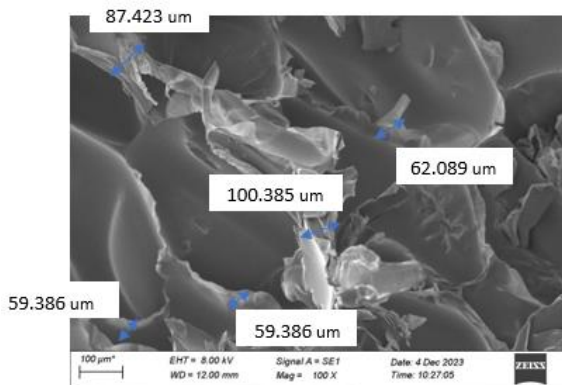
Gambar B.10 SEM PUR-21 Ukuran 50x



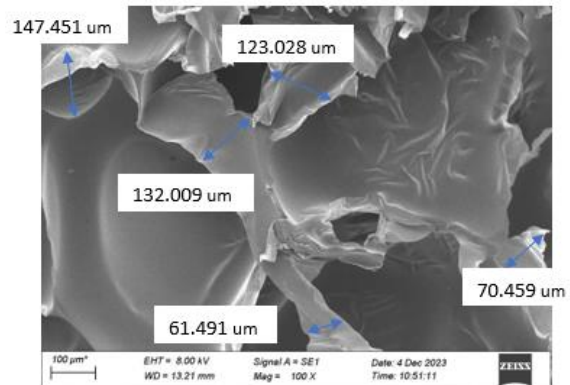
Gambar B.11 SEM PUR-22 Ukuran 50x



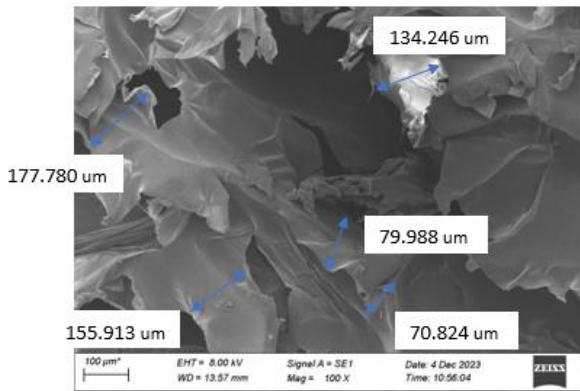
Gambar B.12 SEM PUR-23 Ukuran 50x



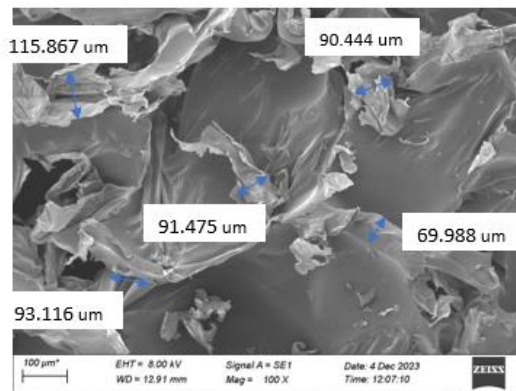
Gambar B.13 SEM PUR-11 Ukuran 50x



Gambar B.14 SEM PUR-21 Ukuran 50x



**Gambar B.15** SEM PUR-22 Ukuran 50x



**Gambar B.16** SEM PUR-23 Ukuran 50x

**LAMPIRAN C**  
**GAMBAR ALAT DAN BAHAN**

## Lampiran C. Gambar Alat dan Bahan

### C.1 Alat



**Gambar C.1** Cetakan



**Gambar C.2** Cutter



**Gambar C.3** Gunting



**Gambar C.4** Gelas Beker



**Gambar C.5** Mata Gergaji



**Gambar C.6** Pipet Tetes



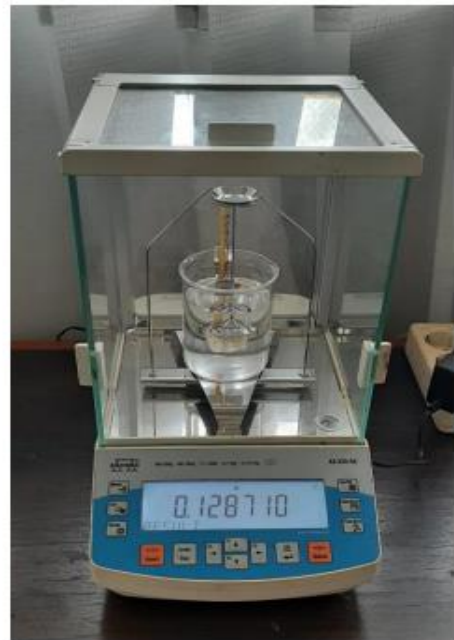
**Gambar C.7** Plastik Sampel



**Gambar C.8** Spatula *Metal*



**Gambar C.9** Alat Pengujian Uji Tekan

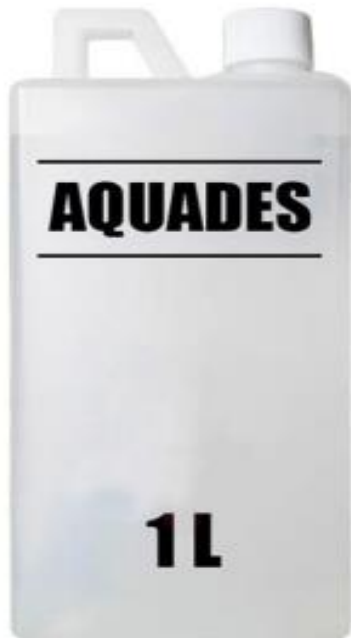


**Gambar C.10** Alat Pengujian Densitas



**Gambar C.11** Timbangan Digital

## C.2 Bahan



Gambar C.12 Aquades



Gambar C.13 MDI



Gambar C.14 Dietilen Glikol



Gambar C.15 Surfaktan Silikon



**Gambar C.16 Botol Plastik PET**



**Gambar C.17 Plastik LDPE**



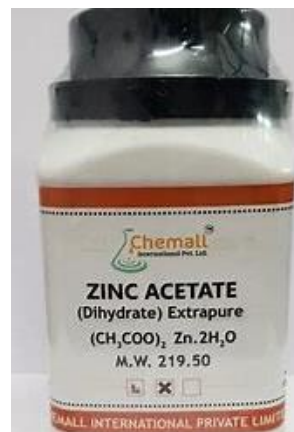
**Gambar C.18 Plastik HDPE**



**Gambar C.19 Plastik LLDPE**

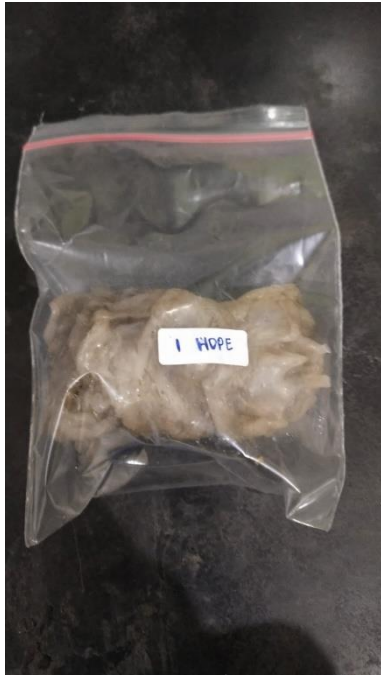


**Gambar C.20 Plastik Sedotan PP**



**Gambar C.21 Zinc Asetat**





**Gambar C.22** Plastik Glikolisis HDPE



**Gambar C.23** Plastik Glikolisis PP



**Gambar C.24** Plastik Glikolisis LDPE



**Gambar C.25** Plastik Glikolisis LLDPE



**Gambar C.26** Larutan Glikolisis



**Gambar C.27** Larutan Glikolisis