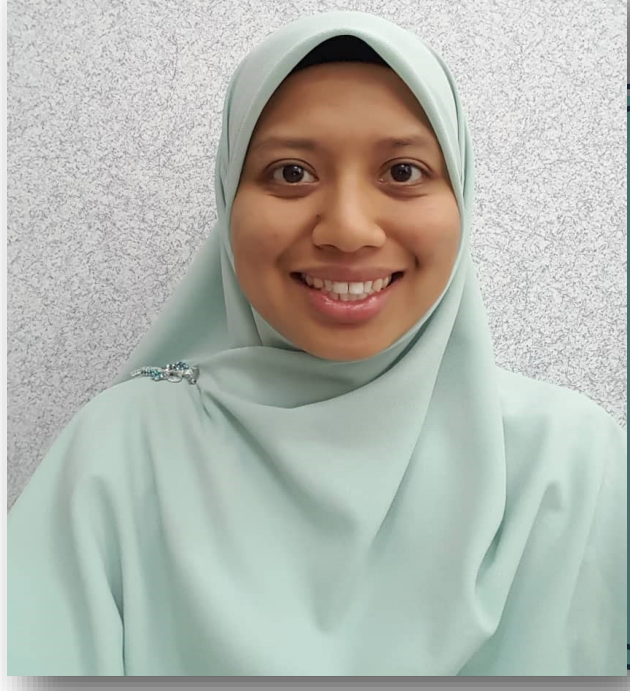
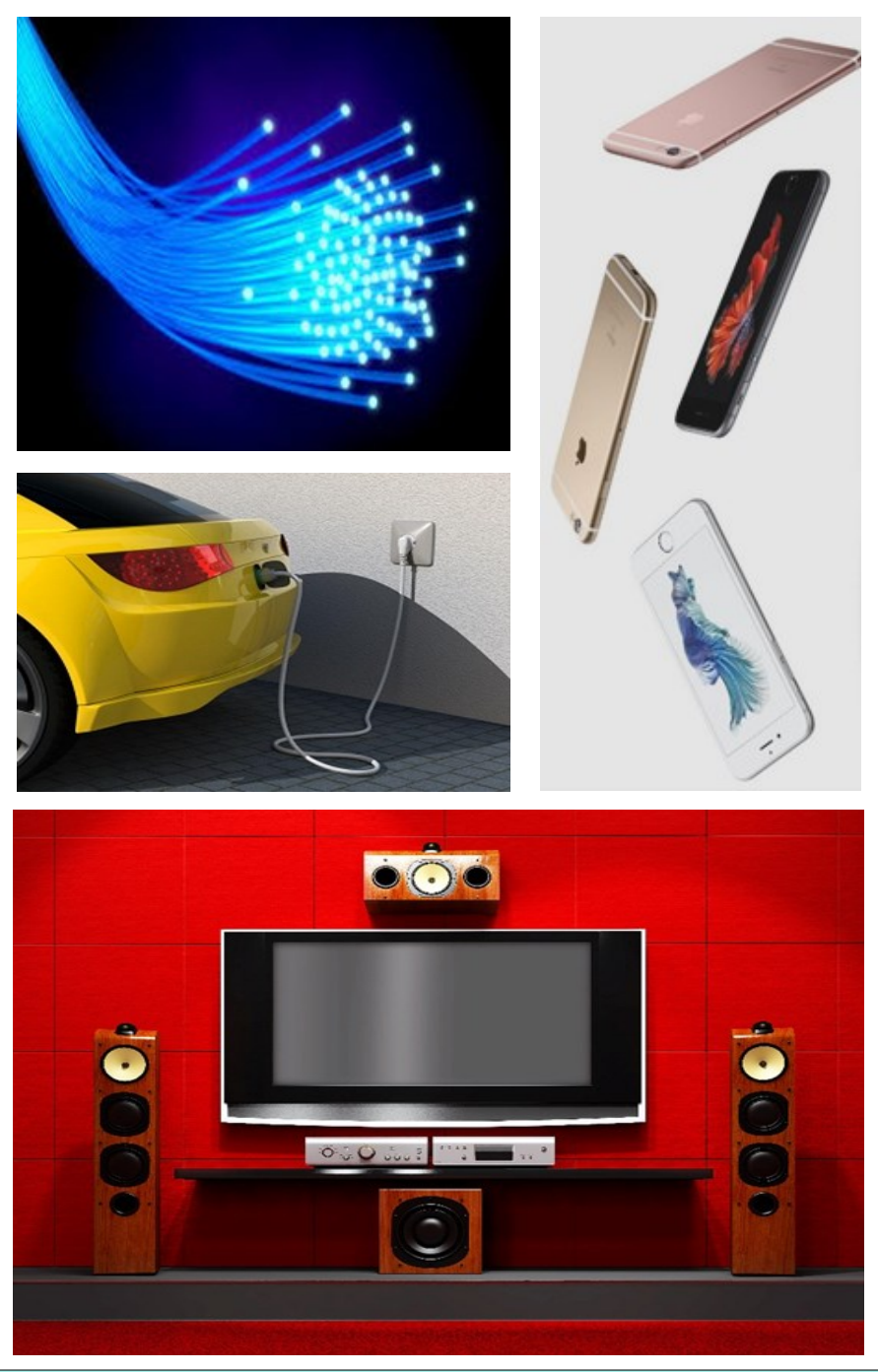


Extraction of Rare Earth Element using Synergist Extractant Immobilised Resins (SEIR)

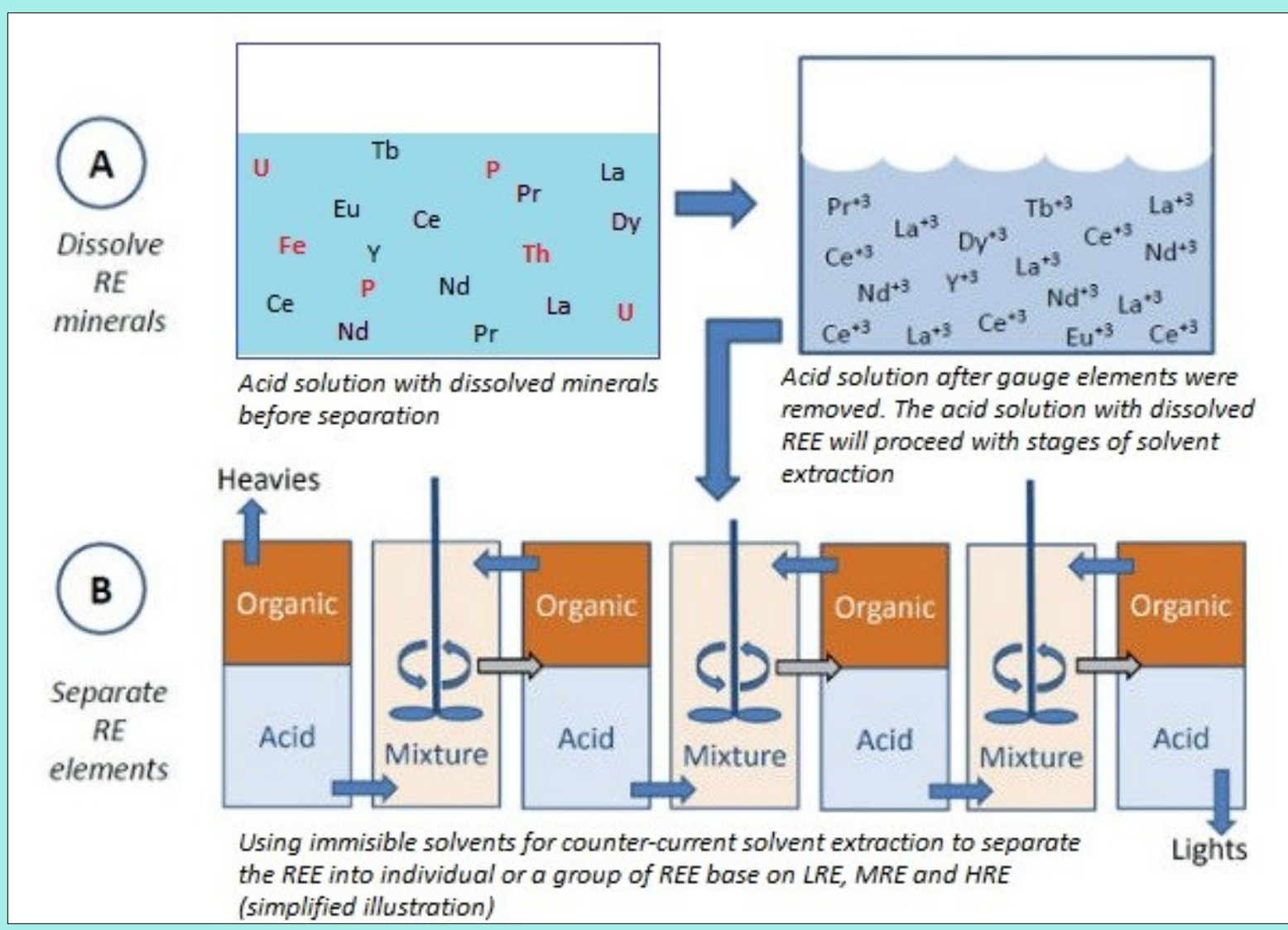


TEAM: **Dr Sumaiya Zainal Abidin (Leader), Nur Nadiatul Hidayah**
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PRODUCT BACKGROUND



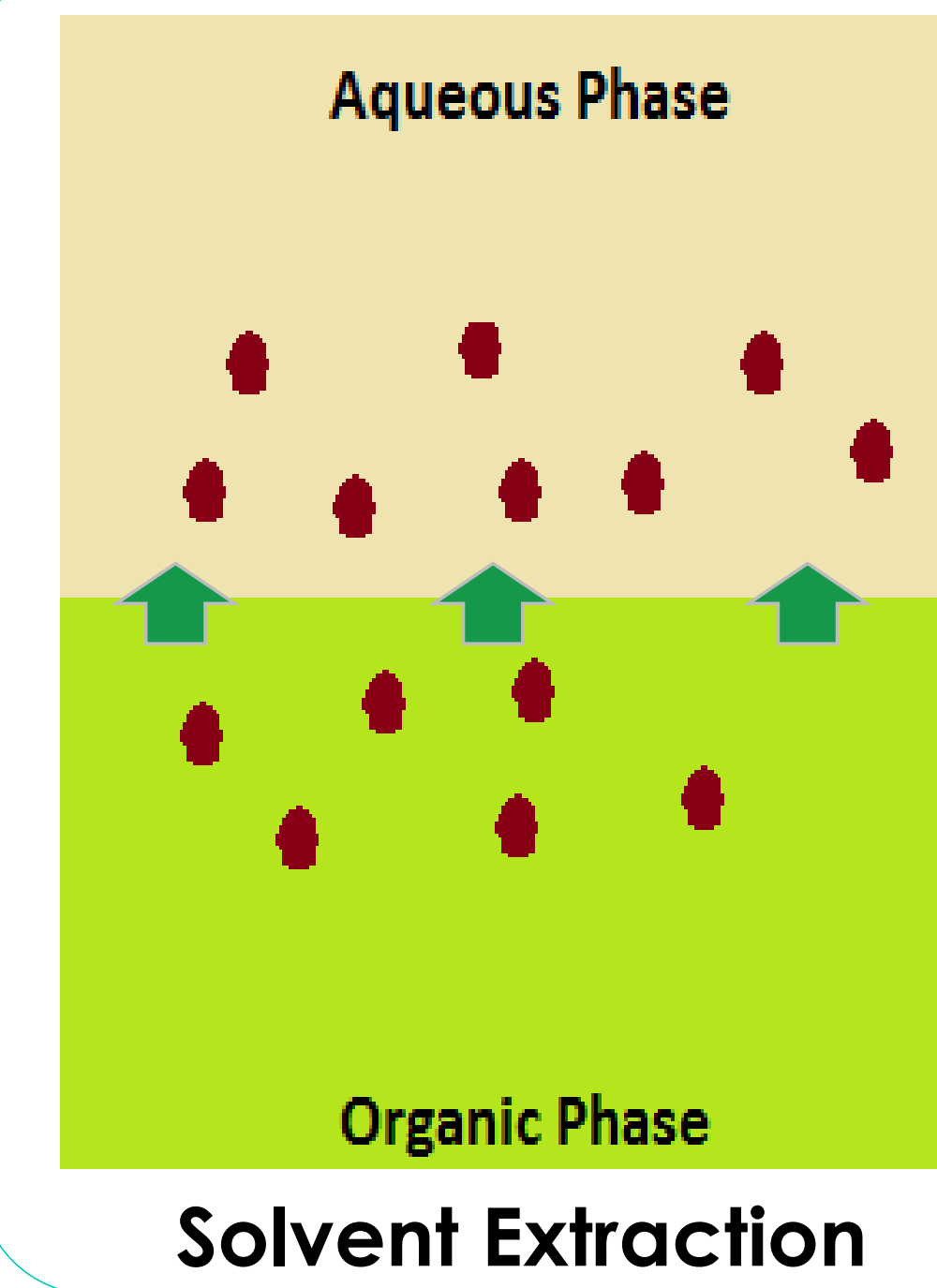
The application of REE



The metals extraction of rare earth elements commonly applied in conventional extraction process in liquid-liquid extraction.

DRAWBACKS

- Poor contact
- Multiple contact cost organic extractant loss & emulsion
- High volatile organic compound (VOC) & formation of third phase
- Tendency of emulsion & poor extraction



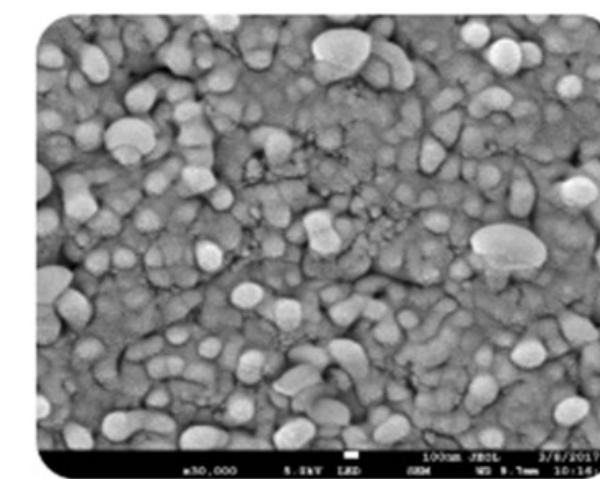
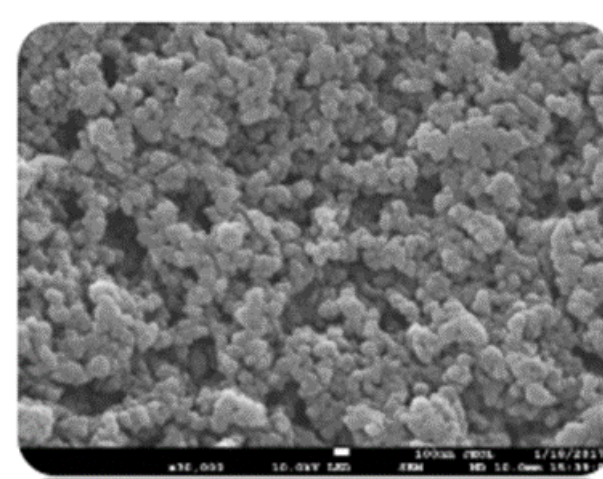
COUNTER MEASURES

- Multiple contact
- Improve organic extractant durability
- Synergist extractant with ionic liquid to reduce VOC

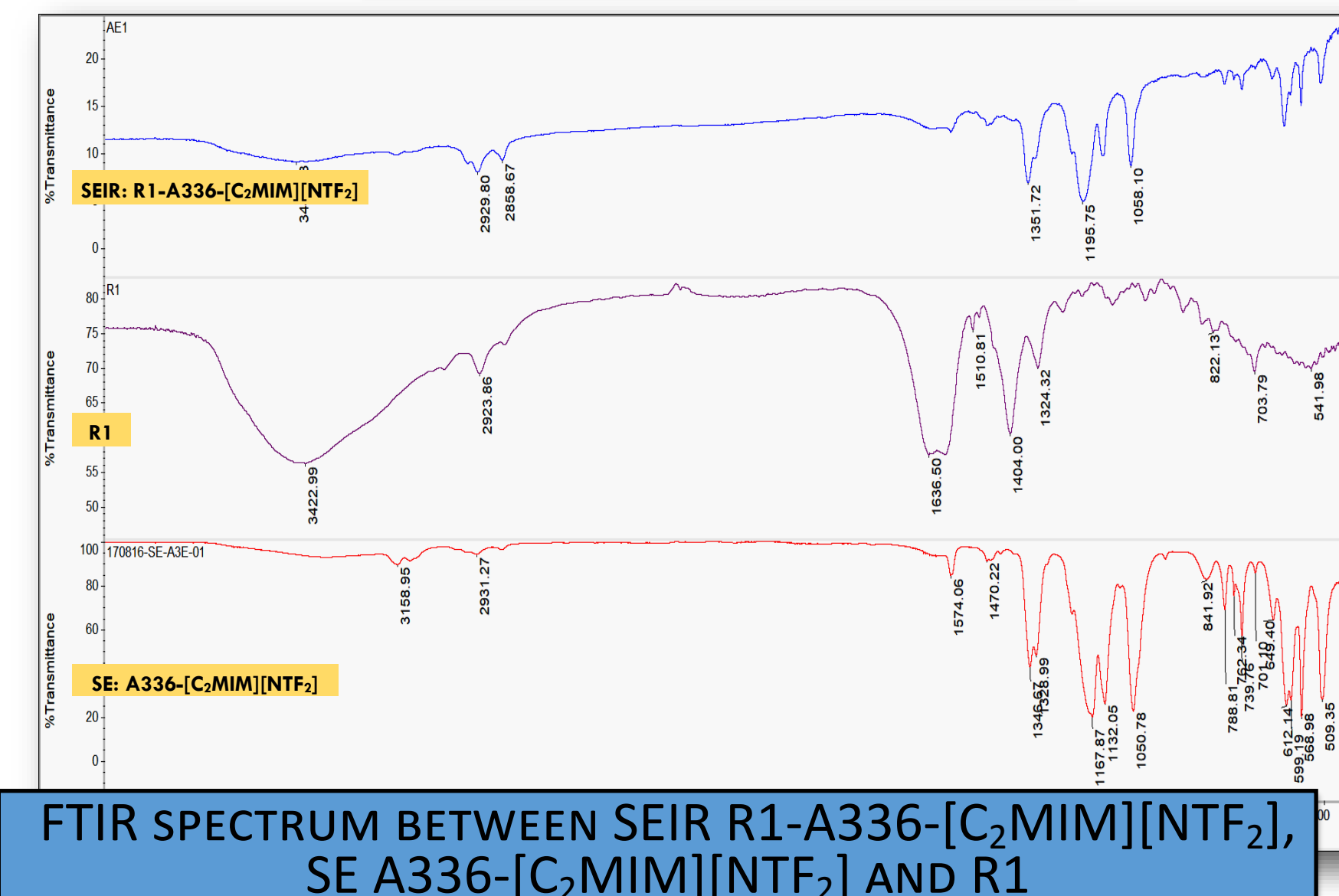
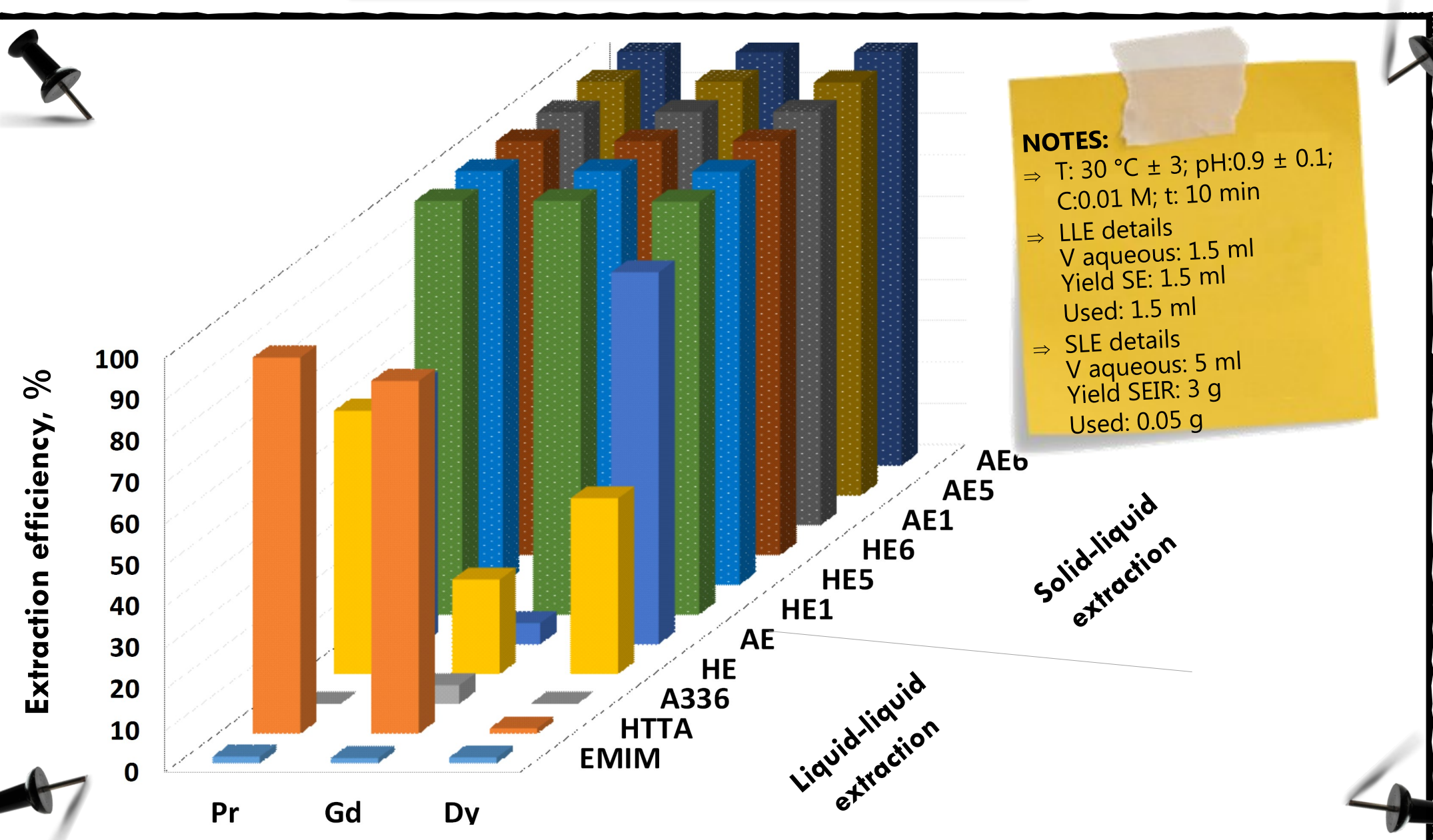
REE are difficult to be extracted from other elements



SEIR PRODUCTS

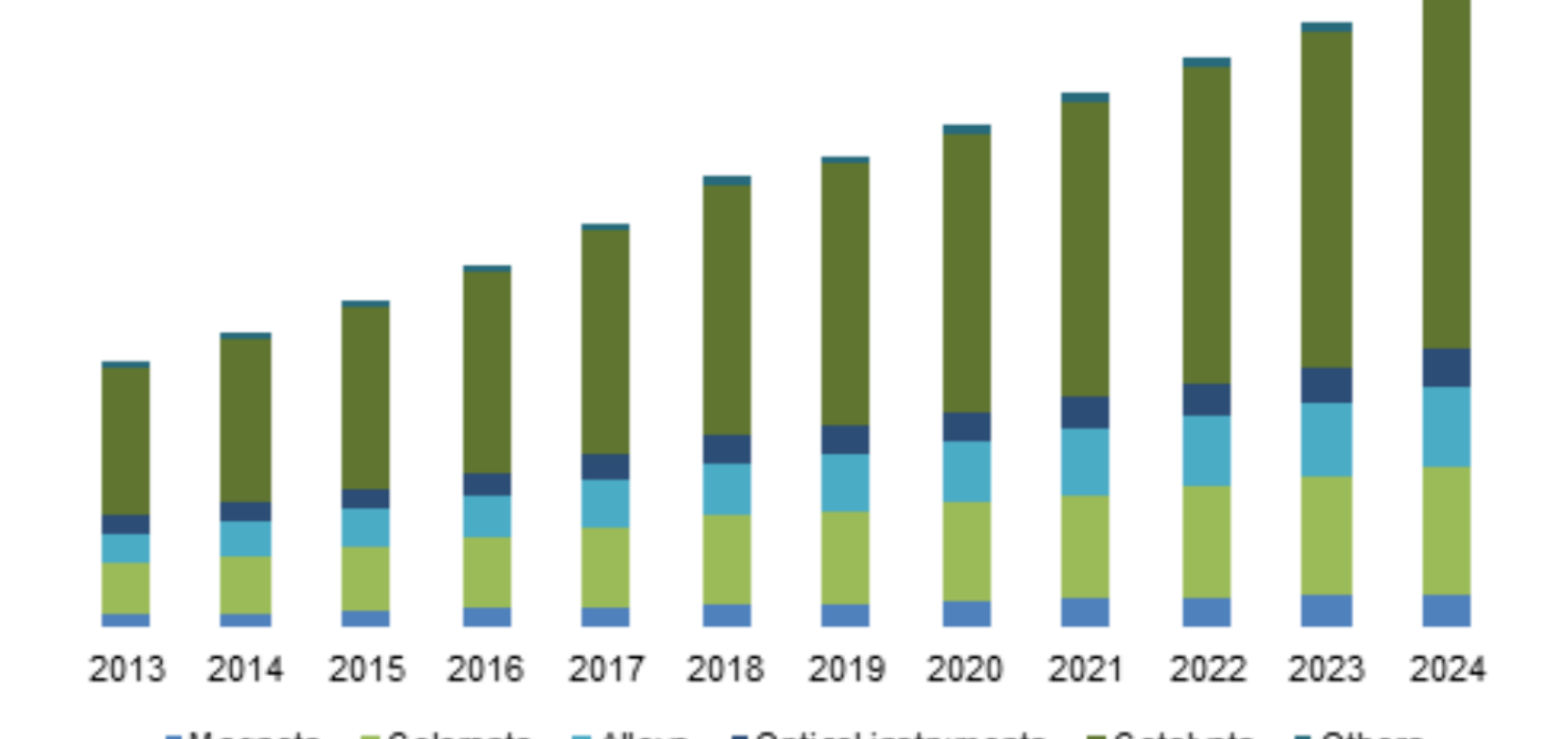


FESEM: R1 SURFACE BEFORE AND AFTER IMMOBILISATION



MARKET SHARE

U.S. rare earth metals market size, by application, 2013 - 2024 (USD Million)



RARE EARTH METALS MARKET SIZE WAS OVER USD 9 BILLION IN 2016 AND WILL GROW AT OVER 9% OVER THE PROJECTED PERIOD.

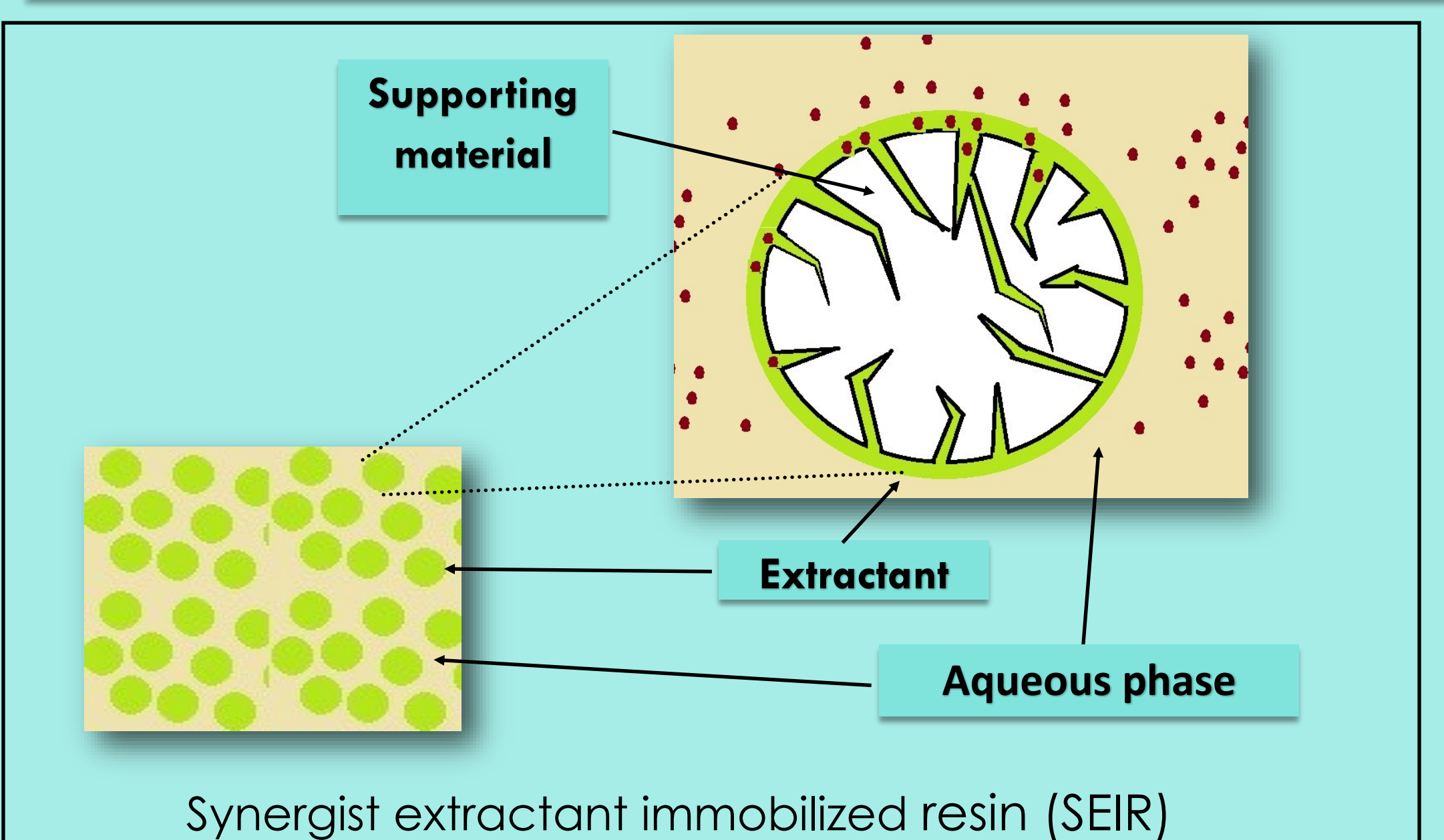
COMMERCIALIZATION / MARKETABILITY

- Collaborator**
- Mitsubishi Chemical - Fund: approximately RM12,000
 - Minerals & Geoscience Department Malaysia (JMG) - MOU
 - LYNAS Corporation Ltd - MOA
- Potential Clients**
- Amanjaya Holdings & Venture Sdn Bhd
 - Aras Kuasa Sdn Bhd
 - MB Inc Perak
 - Asian Metal Mining Consultancy Sdn Bhd
 - Freeport Exploration Indonesia

NOVELTIES

- Extraction of REE using new combination of synergist extractant between conventional extractant with ionic liquid.
- Improve the conventional technique in extraction of REE from LLE into SLE using industrial resin immobilised with synergist extractant.

STATE OF EXTRACTION USING SEIR



BENEFITS

- Enhance extraction of REE
- Minimize VOC
- Remove emulsion
- Reduce the use of extractant up to 50%

FUND / GRANTS

Ministry of Higher Education [grant number: RDU150115]

PATENT

The patent has been filed and the submission date is on 26 March 2018.

AWARDS / ACHIEVEMENTS

- Green Technology Award, CITREX 2018 - Extraction of Rare Earth Elements using synergist extractant immobilised resin (SEIR)
- Gold Medal, CITREX 2018 - Extraction of Rare Earth Elements using synergist extractant immobilised resin (SEIR)

ENVIRONMENTAL IMPACT

- The quantity of chemicals used in extraction of REE reduced up to 50%.
- The impact of volatile organic compound is at minimal due to the application of green solvent of ionic liquid.

PUBLICATIONS

- Adsorption of Dy using Synergist Extractant Immobilised on Resin. *Jurnal Teknologi*, Feb 2019
- The Evolution of Mineral Processing in Extraction of Rare Earth Elements using Liquid-Liquid Extraction: A review. *Minerals Engineering*, vol. 121, pp. 146 - 157, 2018.
- Liquid-liquid extraction of cerium using synergist extractant. *Journal of Mechanical Engineering and Sciences (JMES)*, 12 (1), pp. 3302-3312., 2018
- The Evolution of Mineral Processing in Extraction of Rare Earth Elements using Solid-Liquid Extraction: A Review. *Minerals Engineering*, vol. 112, pp. 103 -113, 2017.
- The Comparison on the Extraction Effects of Dy, Gd and Pr using Synergist Extractants and Independent Extractants in Liquid-Liquid Extraction. *APPCHE proceeding conference (Hong Kong)*, 2017.

COST IMPACT

Extraction of 1000 mL aqueous REE

| Conventional method – LLE | | |
|-------------------------------------|--|--|
| Details | Synergist Extractant (SE) | |
| Chemicals | HTTA-C ₂ mim[NTF ₂] | A336-C ₂ mim[NTF ₂] |
| Raw materials/100g (RM) | 2,497 | 1,543 |
| SE required to extract 1000 mL (mL) | 1,000 | 1,000 |
| Cost of SE (RM) | 12,800 | 9,600 |

| Synergist extractant immobilised resin (SEIR) – SLE | | |
|---|--|--|
| Details | SEIR | |
| Chemicals | HTTA-C ₂ mim[NTF ₂] | A336-C ₂ mim[NTF ₂] |
| Raw materials/100g (RM) | 3,097 | 2,143 |
| SE required to extract 1000 mL (g) | 100 | 100 |
| Cost of SEIR (RM) | 1,880 | 1,560 |

SEIR reduce the cost approximately 83-85% less compared to the use of conventional method of LLE. Apart from increase in extraction efficiency, the cost estimation is far cheaper thus decrease the use of extractant.

Note: The cost estimation covered only on the raw materials of both LLE and SLE.