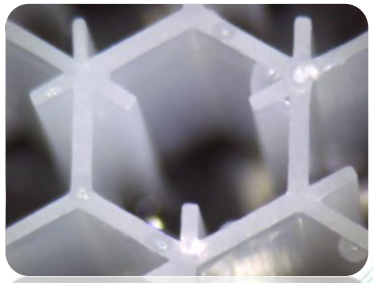

# New MBBR Carriers for High Loading Applications

(ITS/172/12FP)

by
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# Introduction

- Food and beverage industry in HK
  - Discharge industrial effluent of 3,000-4,000 mg/L COD
  - Require pretreatment to achieve <2,000 mg/L COD before discharge to municipal STW in HK.
- Constraints:
  - Physio-chemical treatment (CEPT, EC) inadequate to meet pretreatment requirement
  - Space limitation esp. in multi-story factory buildings, imposes great challenge to biological treatment
  - Safety and odour concerns and relatively long retention time render anaerobic processes unsuitable to be used

Compact aerobic biological processes, like MBBR, offer the most viable solution to the local food and beverage industry

# Project Objective

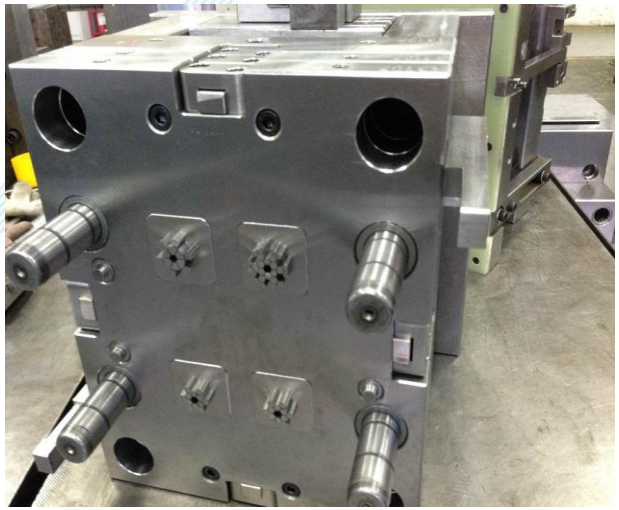
- Identify the maximum organic loading of MBBR process so as to develop the most compact bioreactor configuration

- Develop new MBBR carrier to fit for the targeted high loading applications with focus on:
  - increase effective specific surface area
  - optimize the carrier configuration
  - enhance carrier surface properties

# New mobile carriers

- **Geometric design**
  - Maximizing the protected surface area
  - Maintaining adequate size of void space to avoid clogging problem under high loading conditions

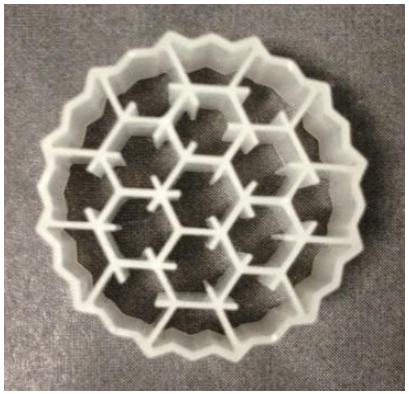
- **Surface modification**
  - Change the surface properties by blending material into HDPE, e.g. calcium carbonate (10%), addition of foam (3% nitrogen gas)
  - Plasma surface treatment to change hydrophilicity



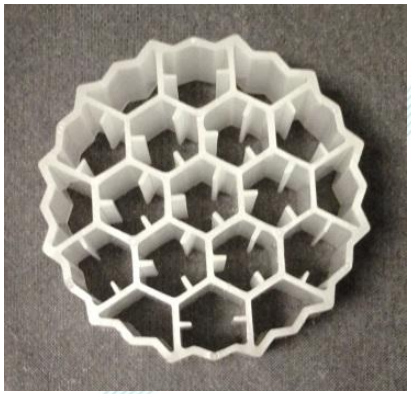
# New Mobile Carriers - Geometric Design

No fin

Corner fin



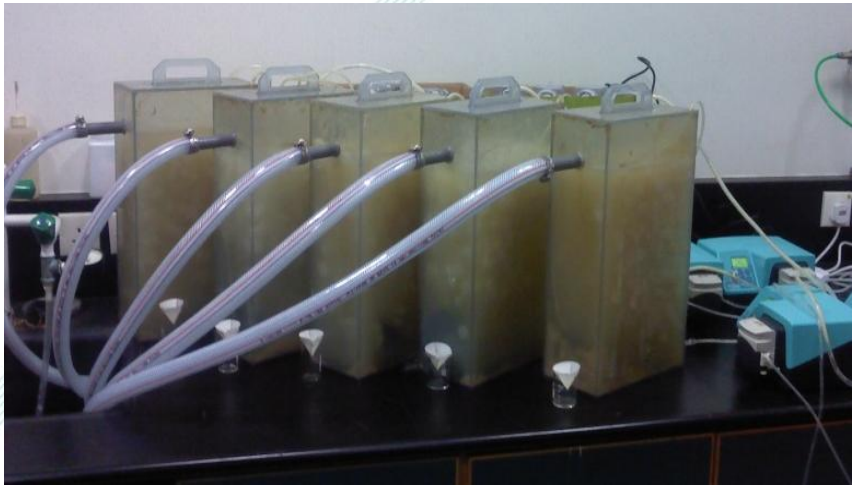
Side fin



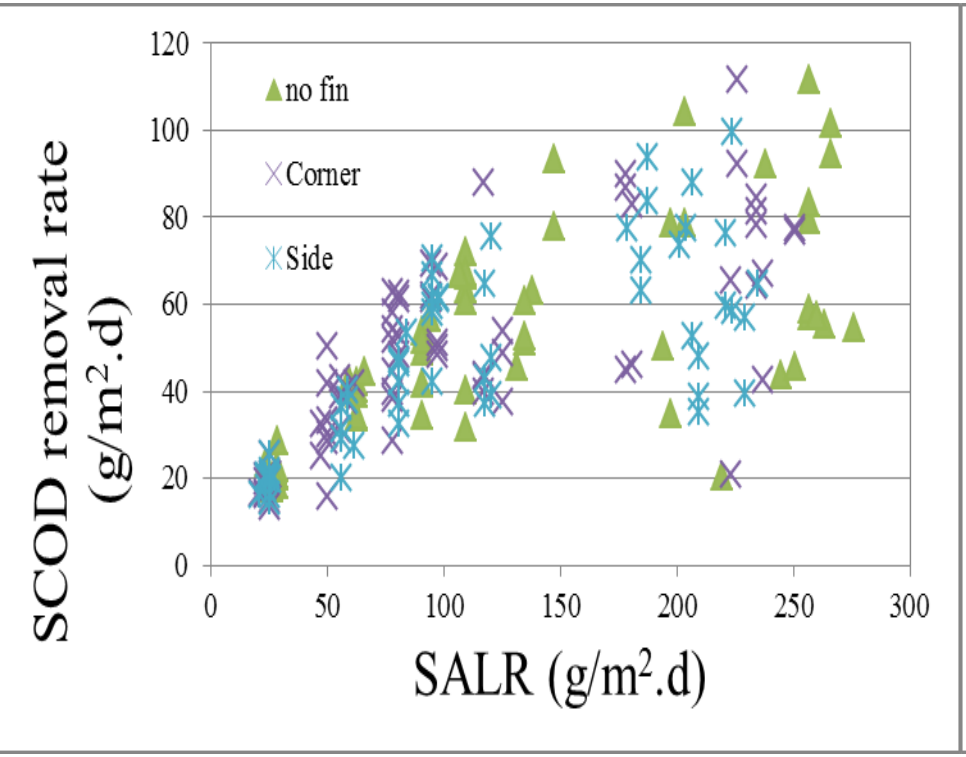
| Parameters | No fin | Corner fin | Side fin |
|---|---|---|---|
| Carrier diameter (mm) | 25 | 22 | 22 |
| Bulk density (number of carriers/liter) | 130 | 168 | 168 |
| Specific surface area ($m^2/m^3$) | 547 | 615 | 613 |

# Performance Evaluation

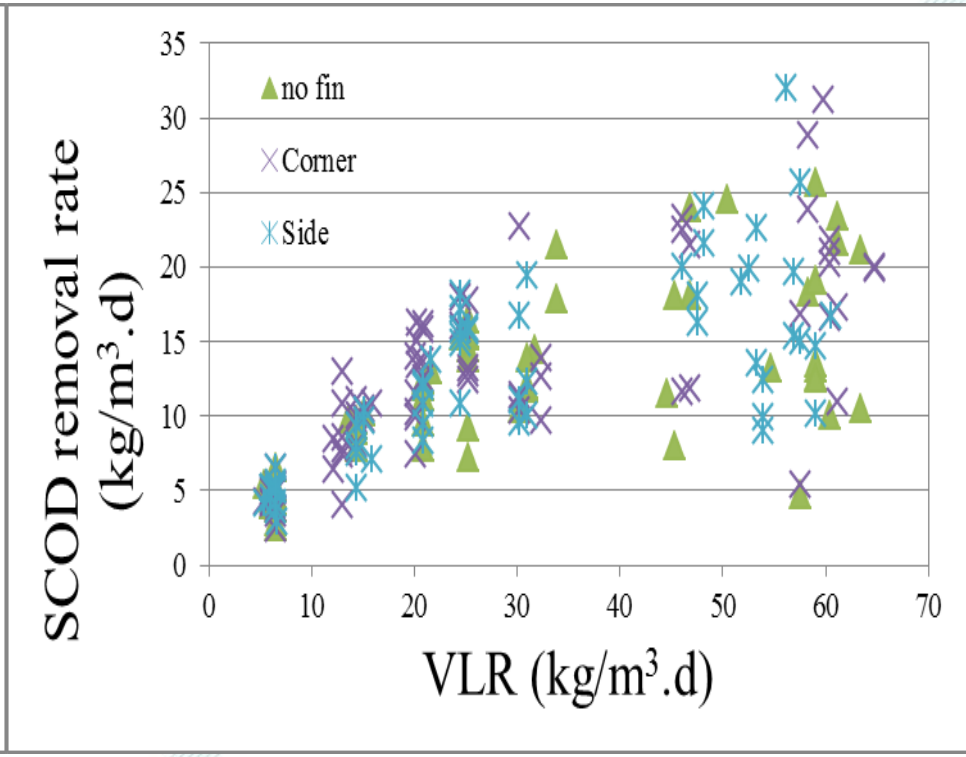
- **Biofilm Build-up**
  - diluted soymilk with ~1,000 mg/L COD
  - activated sludge as seeding (to stimulate bacteria growth and adhesion)
  - batch running mode (SBR): F/M of 0.8 kg COD/kg MLSS.d for 2 weeks
- **Experimental Set-up**
  - Diluted soymilk with ~3,000 mg/L COD
  - 12 L rectangular MBBR
  - 42% fill ratio
  - On-line pH adjustment
  - DO>2.0 mg/L
  - Continuous running mode
  - OLR at 24~240 g SCOD/$m^2$.d (HRT at 12~1.2 hr)



# Performance Evaluation of Different Carriers

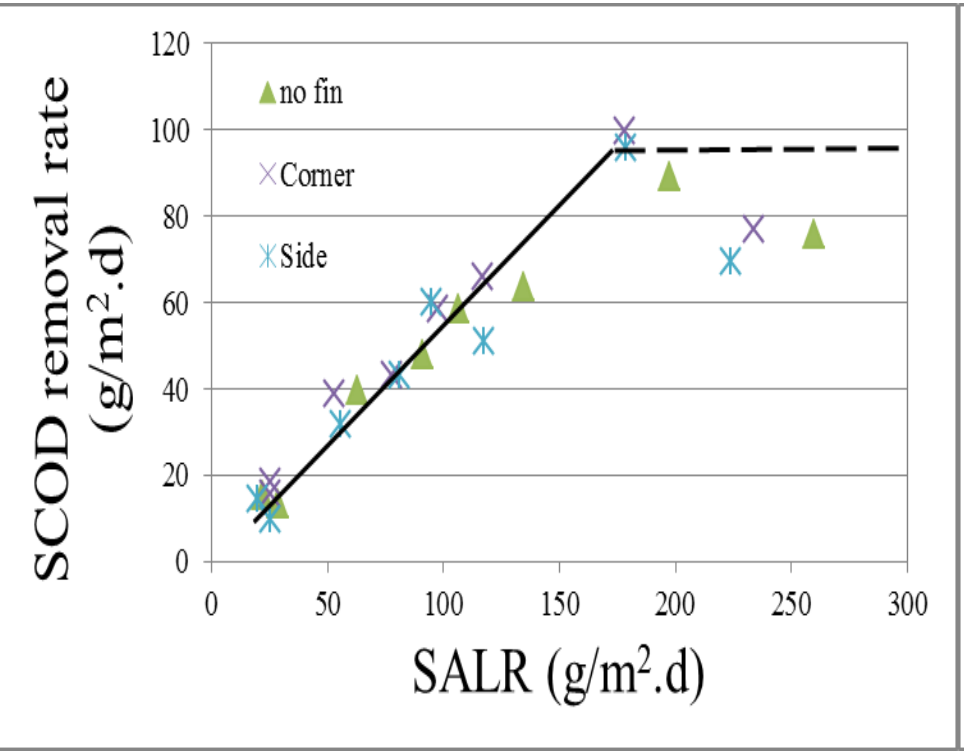



SCOD removal rates vs.
surface area organic loading rates

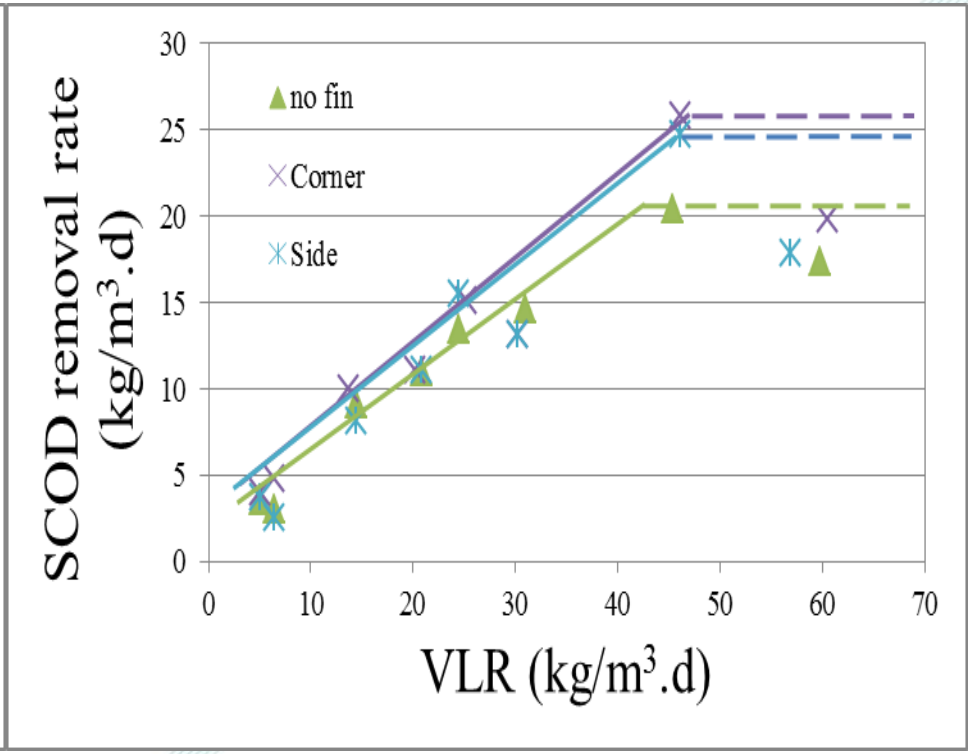



SCOD removal rates vs.
volumetric loading rates

# Performance Evaluation of Different Carriers

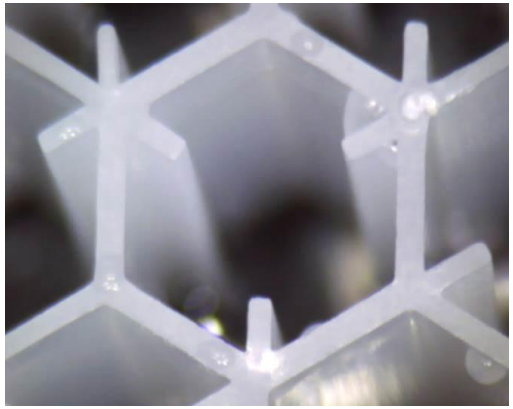



Averaged SCOD removal rates vs. surface area organic loading rates




Averaged SCOD removal rates vs. volumetric loading rates

# Microscopic Observation



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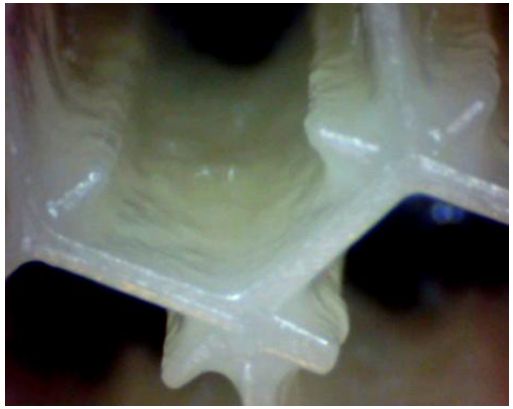

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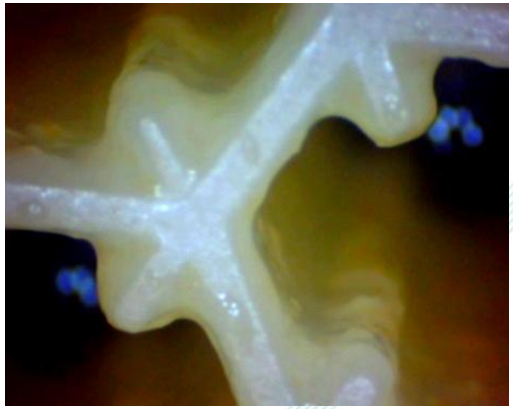

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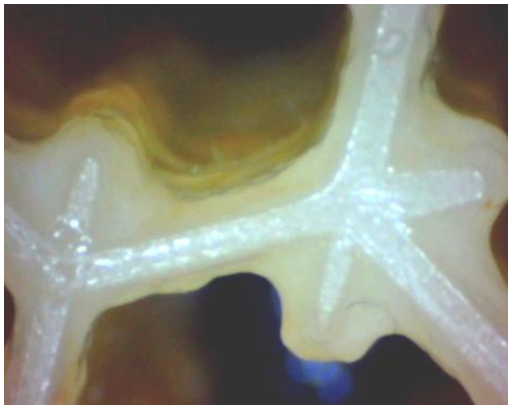

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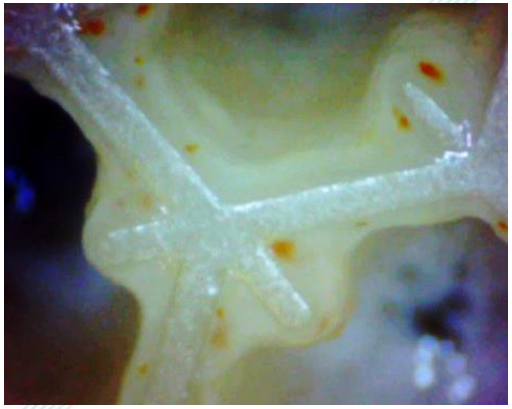
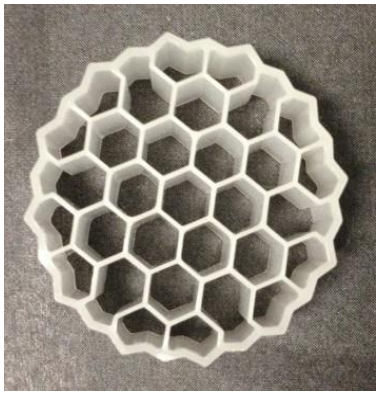


175

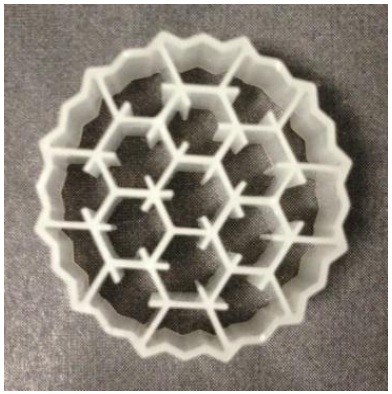
Note: SALR expressed as g SCOD/$m^2$.d

# New Mobile Carriers – Surface Modification

No fin



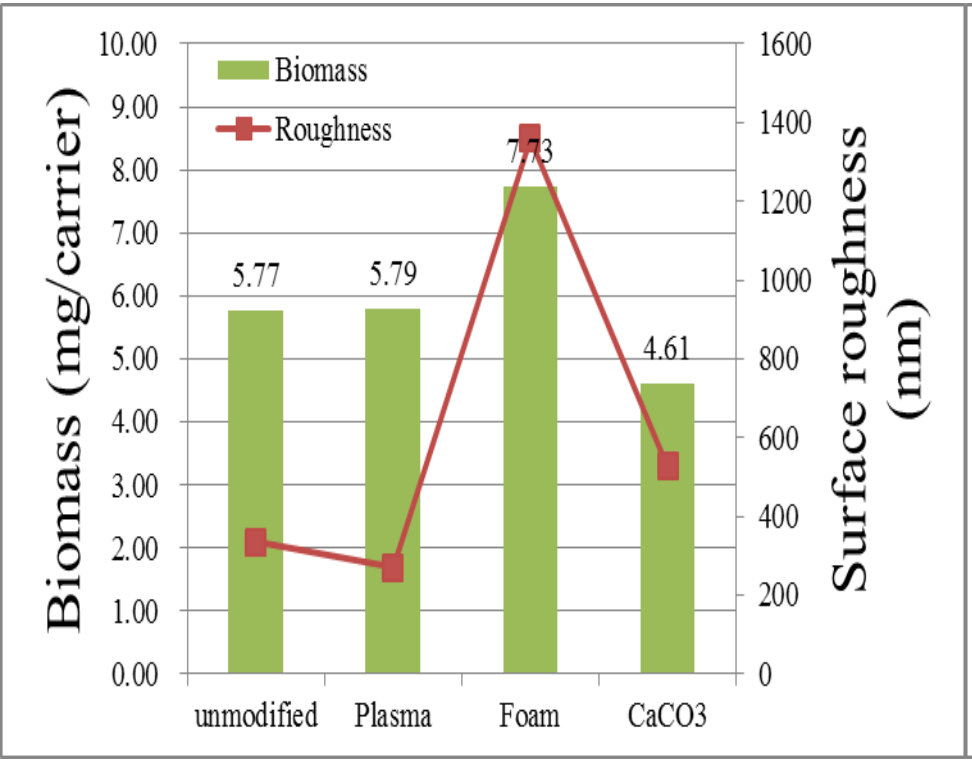
Corner fin



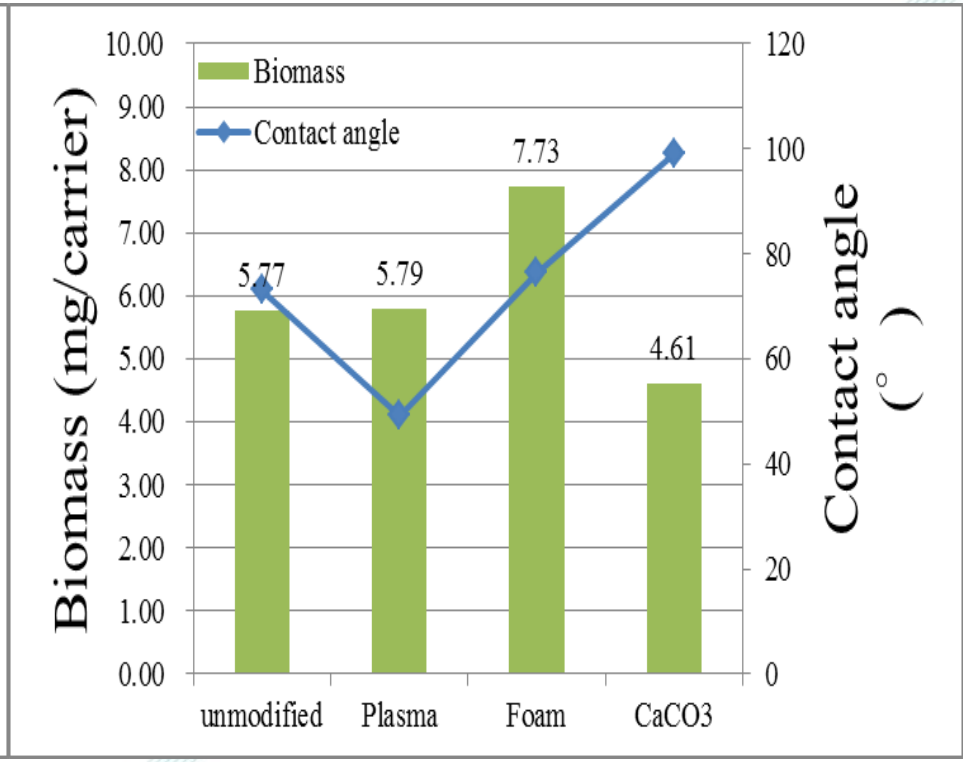
Side fin

| No. | Modification method | Surface roughness (nm) | Contact angle (∘) |
|---|---|---|---|
| | Unmodified carrier | 336 | 73.1 |
| 1 | Plasma treatment | 270 | 49.2 |
| 2 | Foam addition | 1360 | 76.4 |
| 3 | $CaCO_3$ addition | 526 | 99.0 |

# Effect of Carrier Surface Properties on Biofilm Build-up

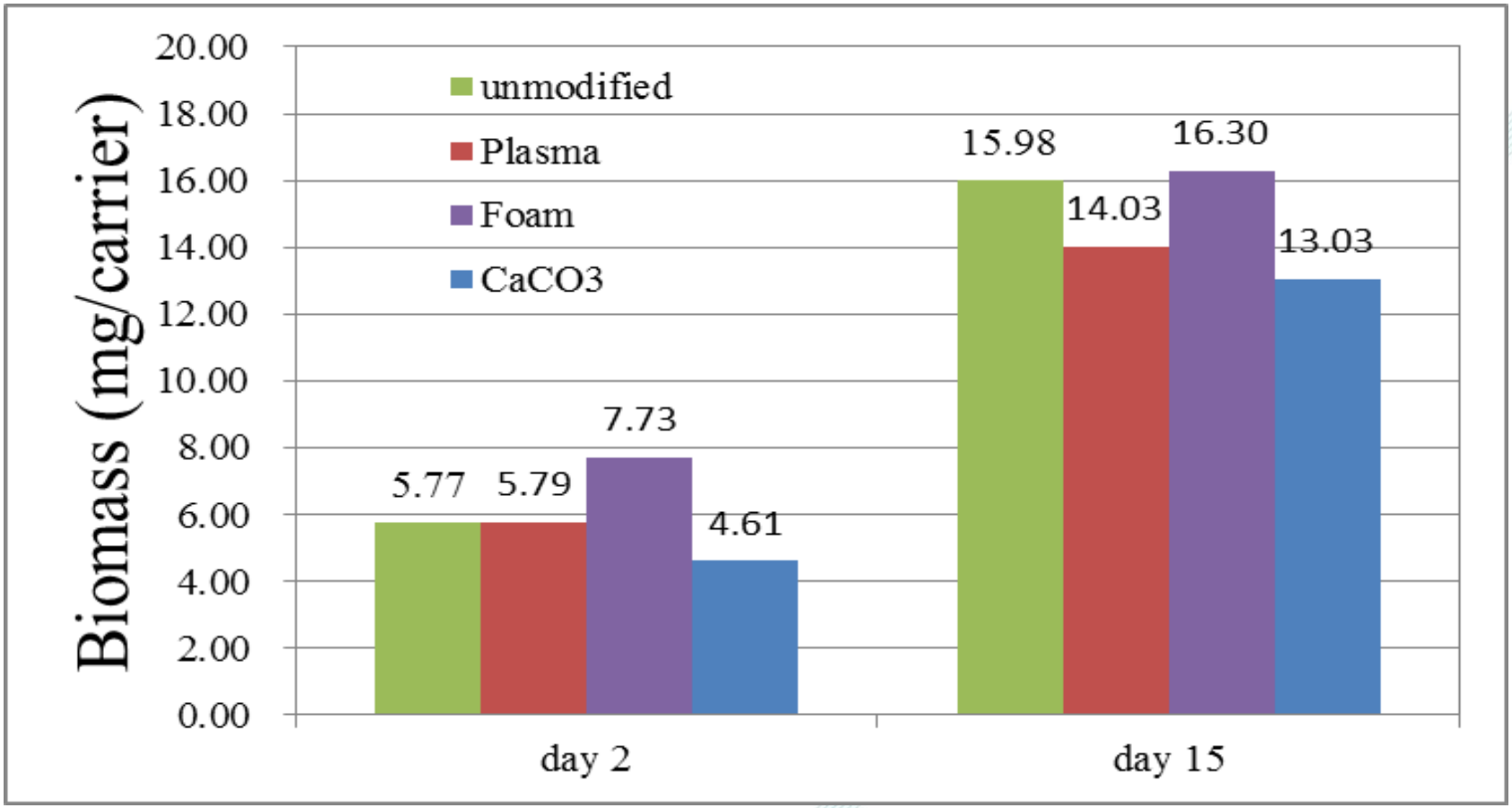



Biofilm build-up vs. surface roughness




Biofilm build-up vs. surface contact angle

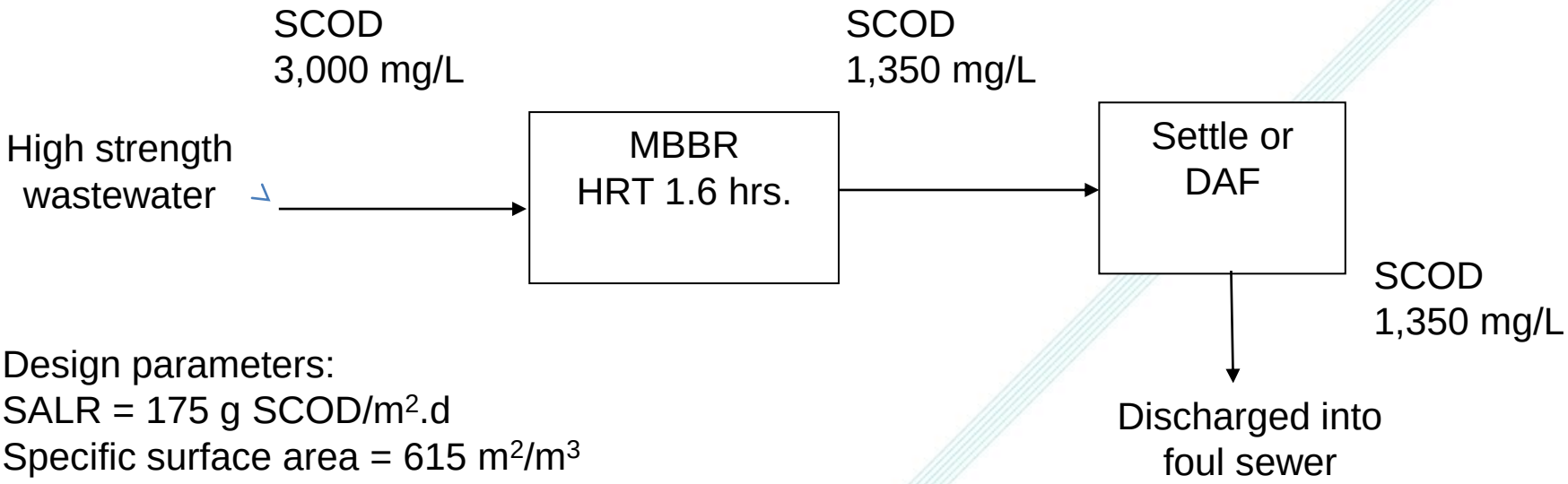
# Effect of Carrier Surface Properties on Biofilm Build-up




Biofilm growth during the initial biofilm build-up period

# Potential High Loading Application - Conceptual Treatment Process

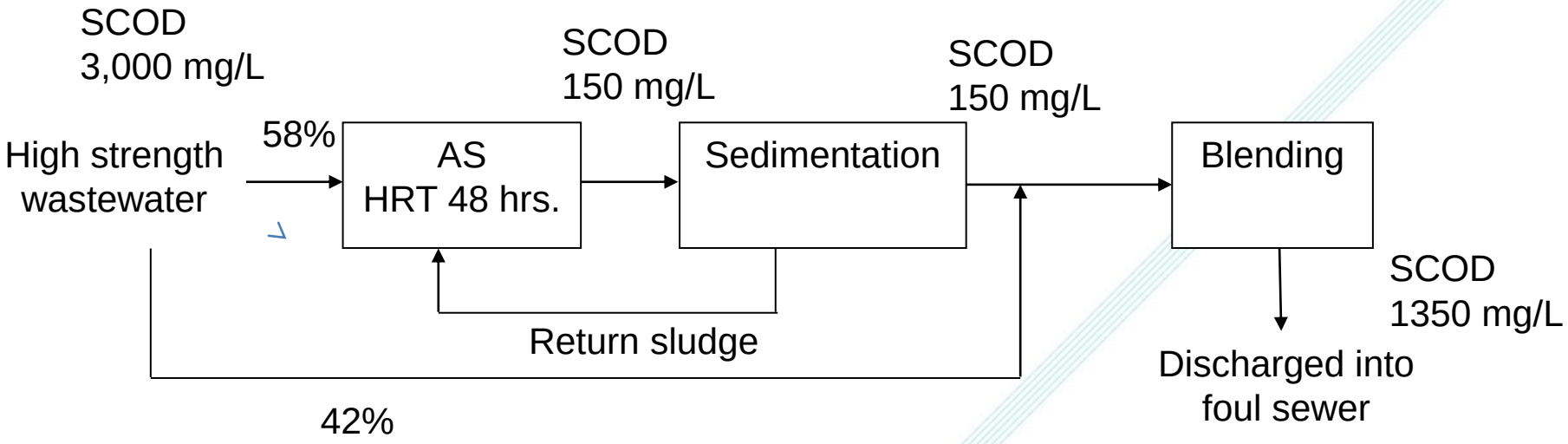
## Scheme 1 – MBBR




Design parameters:
SALR = 175 g SCOD/$m^2$.d
Specific surface area = 615 $m^2/m^3$
Media fill ratio = 42%

# Potential High Loading Application - Conceptual Treatment Process

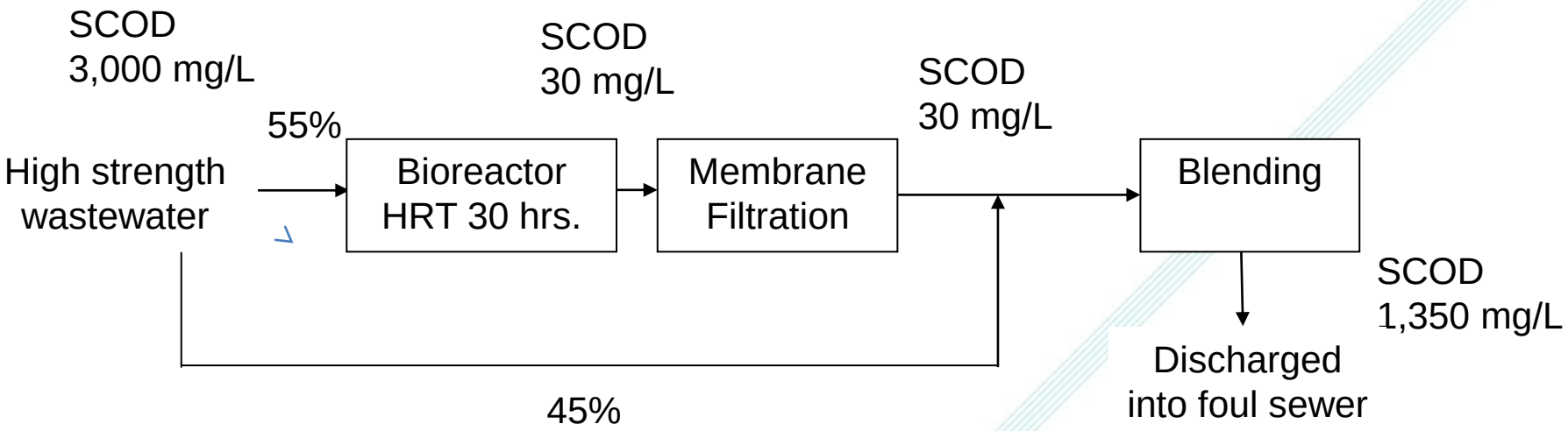
## Scheme 2 – Activated Sludge




Design parameters:
VLR = 1.5 kg SCOD/$m^3$.d
MLSS = 3,000 mg/L
SCOD removal = 95%

# Potential High Loading Application - Conceptual Treatment Process

## Scheme 3 – MBR




Design parameters:
F/M ratio = 0.2 kg SCOD / kg MLSS.d
MLSS = 12,000 mg/L
COD removal = 99%

# Potential High Loading Application - Conceptual Treatment Process

| Treatment Process | Portion of wastewater for biological treatment | HRT of biological reactor for treated stream (hr) | HRT of biological reactor for total wastewater (hr) |
|---|---|---|---|
| MBBR | 100% | 1.6 | 1.6 |
| AS | 58% | 48 | 27.8 |
| MBR | 55% | 30 | 16.5 |

# Conclusions

- The new carriers with 615 $m^2/m^3$ surface area can be operated at very high loading up to a maximum of about 175 g SCOD/$m^2$.d (equivalent to about 46 kg SCOD/$m^3$.d), achieving about 54% SCOD removal.

- Carrier surface roughness and hydrophilicity affect the biofilm build-up on the carrier surface, which suggests a faster start-up of MBBR.

- As compared with AS and MBR, MBBR is the most compact process for pretreatment of the high strength organic wastewater for discharge into the foul sewer. This offers a viable solution to assist the local food and beverage industry to achieve the compliance in the Hong Kong context.

# Further Studies on MBBR Carrier Optimization

- Pilot trial run using new MBBR carrier will be conducted to verify the actual treatment performance on treating industrial effluent as well as domestic sewage.

- Carrier surface roughness seems to be beneficial to the formation of biofilm. Further attempts will be tried to increase the roughness or even the porosity of the carrier.

# Acknowledgement


- Innovation and Technology Commission, the Government of Hong Kong SAR to provide funding support to this project

- DSD to allow us to conduct pilot trial run at Stonecutters Island STW

# Thank You