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APPENDICES

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

Appendix A

Nomenclature

<i>Symbol</i>	<i>Description</i>
a	Specific interfacial area (m^2/m^3)
A_d	Downcomer cross sectional area (m^2)
A_r	Riser cross sectional area (m^2)
C_L	Concentration of DO at a particular time in the bioreactor
C_L^*	Concentration of DO in the liquid that is in equilibrium with the partial pressure of O_2 in the air
C_{Lo}	Initial dissolved oxygen concentration
C_X	Mass concentration of fermenting organisms in fermented
k_La	Volumetric mass transfer coefficient (s^{-1})
r_{O_2}	Specific O_2 uptake rate per unit mass of fermenting organisms
t	Time (s)
u_{sg}	Superficial Velocity of gas (cm/s)
ϵ	Gas holdup (-)
μ	Viscosity (Pa.s)
ρ	Density (kg/m^3)
σ	Surface tension (N/m)

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

Appendix B

Table B-1 Physical properties of liquid phase

Liquid phase	Surface tension [mN/m]	viscosities [centipoises]	density [kg/m ³]
water	56.5	0.95	997
sw 15 ppt	58.0	0.96	1004
sw 30 ppt	66.2	0.97	1026
sw 45 ppt	68.7	0.99	1047
NaCl 30 ppt	65.2	1.12	1010

Table B-2 Ratio of downcomer to riser cross sectional areas used in this work

Key	A_d/A_r
DT1	16.55
DT2	2.61
DT3	1.79
DT4	1.21

Table B-3 Liquids phase used in this work

Key	Liquid
w	water
sw 15	sea water 15 ppt
sw30	sea water 30 ppt
sw45	sea water 45 ppt
NaCl 30	NaCl solution 30 ppt

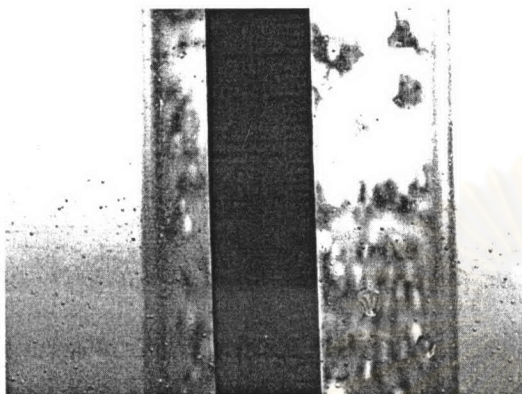
Table B-4 Solubility of dissolved oxygen in liquid phase

Liquid phase	Dissolved oxygen concentration (mg/l)
water	7.54
sw 15 ppt	6.94
sw 30 ppt	6.39
sw 45 ppt	5.89

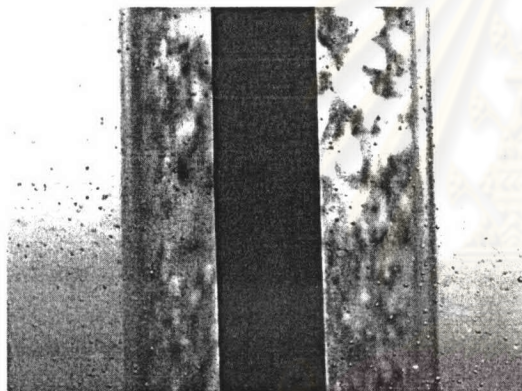
Appendix C

Pictures of bubbles in column with various A_d/A_r and liquid phase

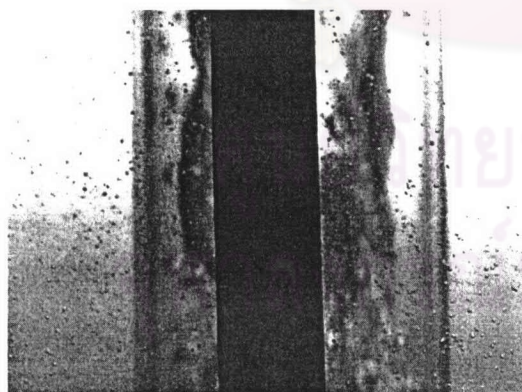
C-1 Water in A_d/A_r 16.55



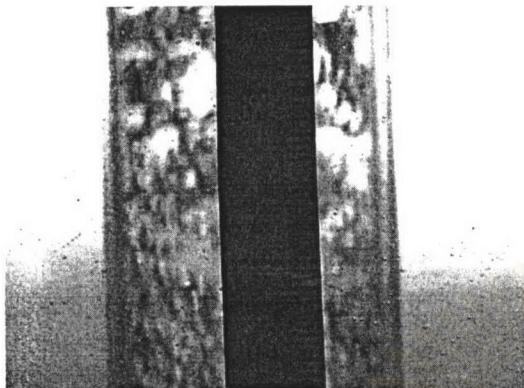
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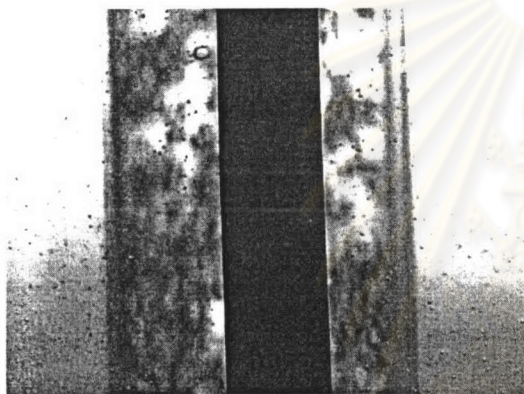
b) Superficial gas velocity 18.8 cm/s



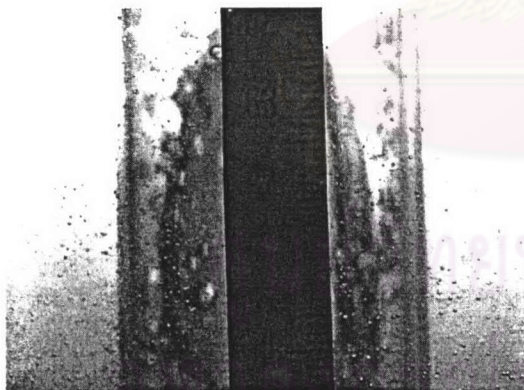
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C-2 Sea water 15 ppt in A_d/A_r 16.55

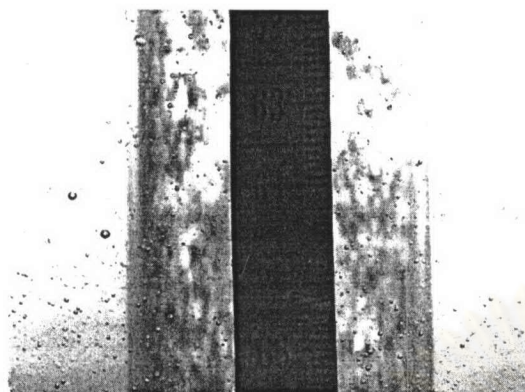
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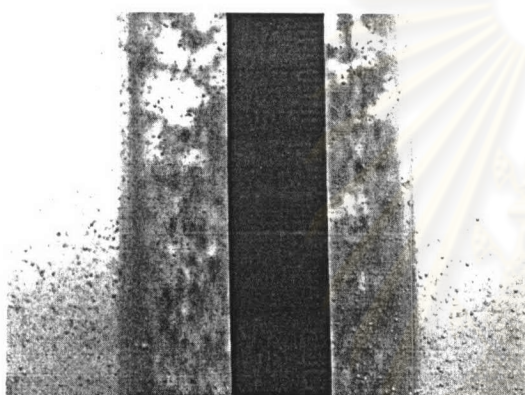
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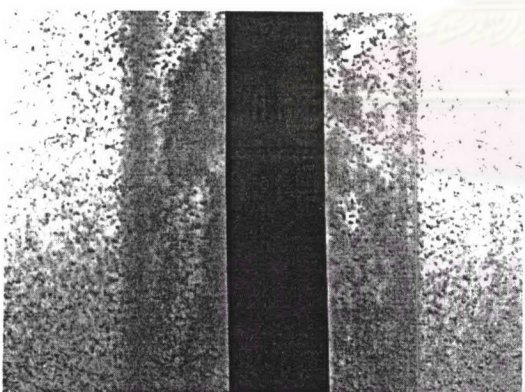
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C-4 Sea water 45 ppt in A_d/A_r 16.55

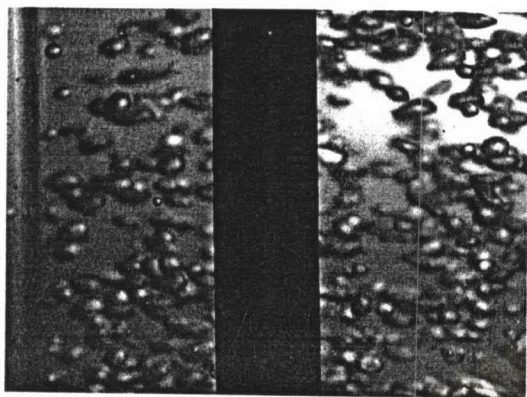
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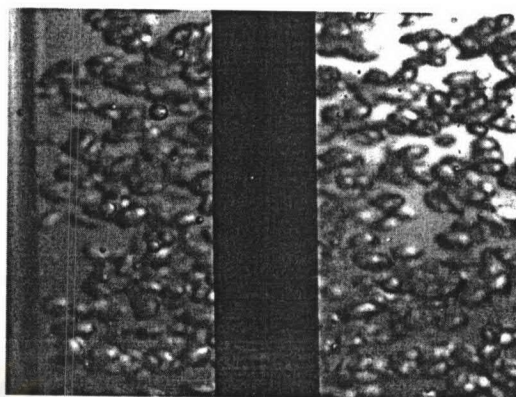
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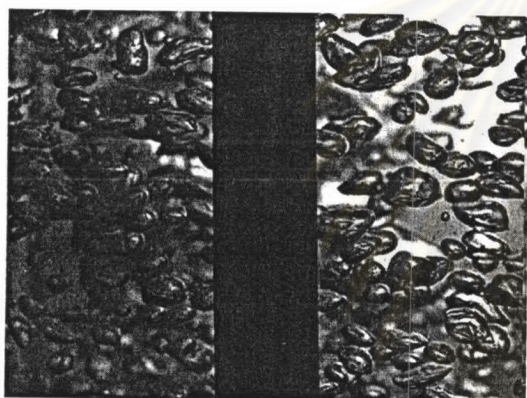
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C-5 Water in A_d/A_r 2.61

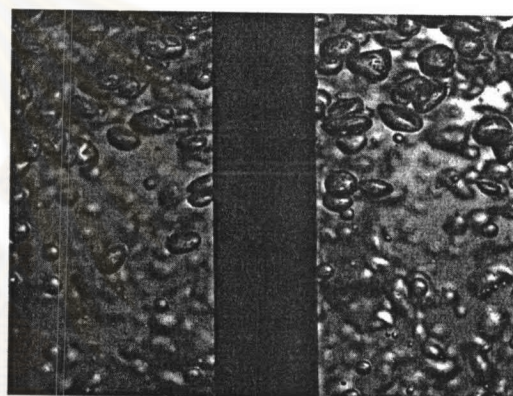
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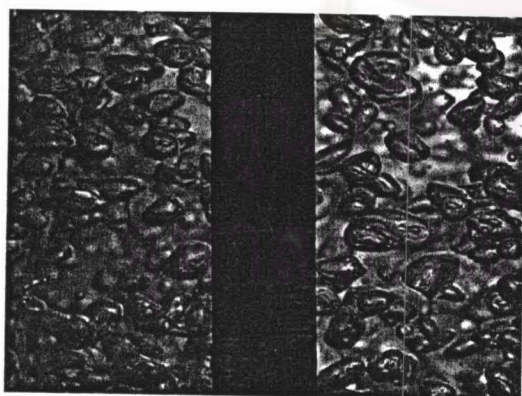
b) Superficial gas velocity 4.0 cm/s



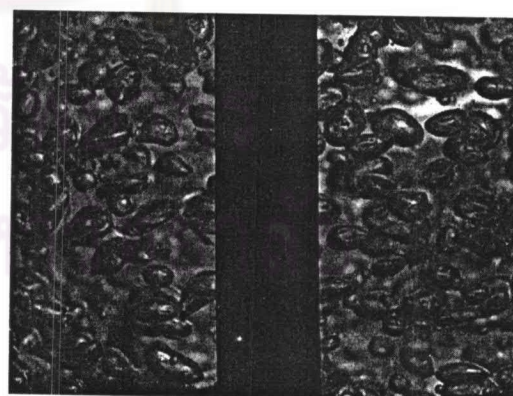
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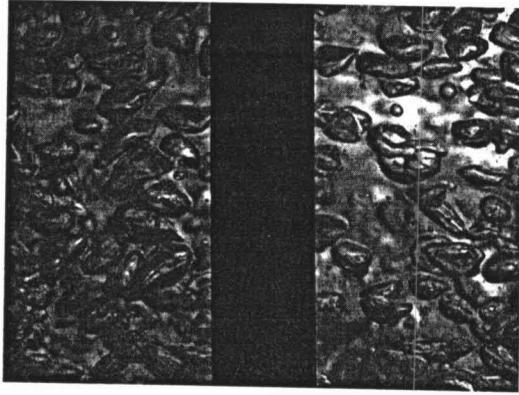
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e) Superficial gas velocity 10.3 cm/s

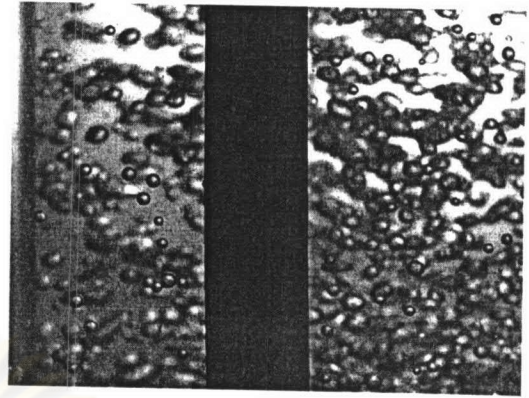


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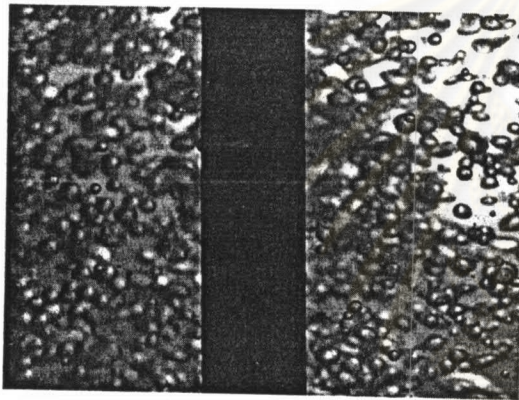


g) Superficial gas velocity 15.5 cm/s

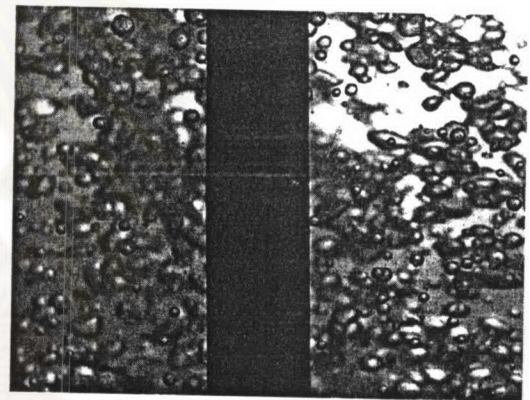
C-6 Sea water 15 ppt in A_d/A_r 2.61



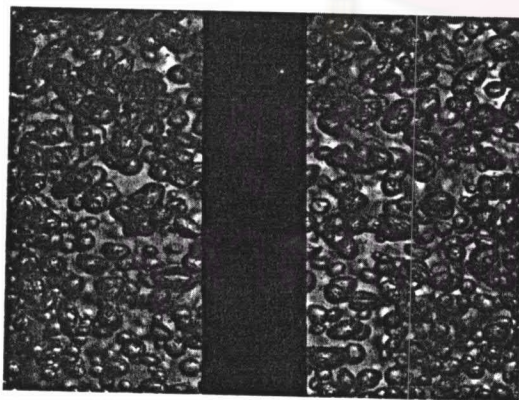
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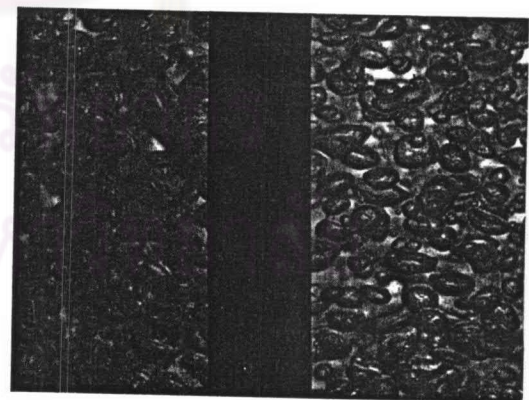
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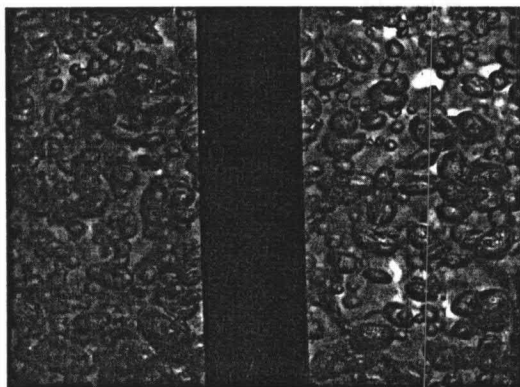
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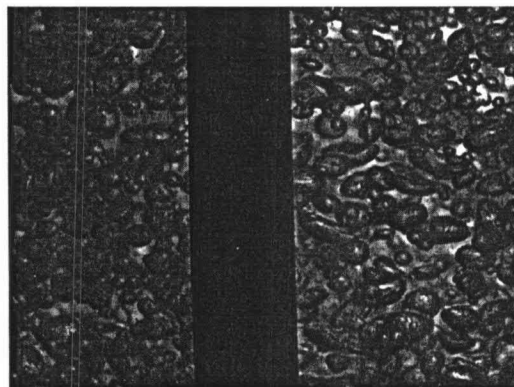
d) Superficial gas velocity 8.0 cm/s



e) Superficial gas velocity 10.3 cm/s

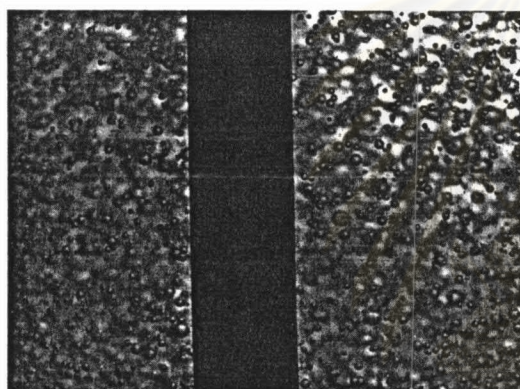


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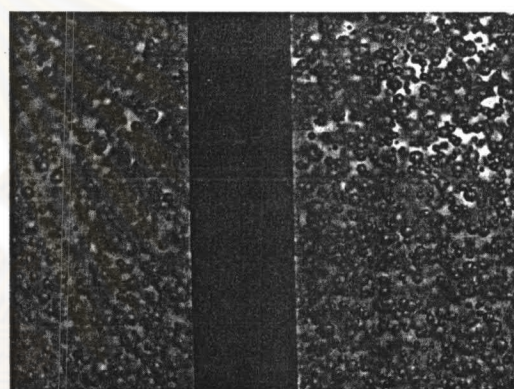


g) Superficial gas velocity 15.5 cm/s

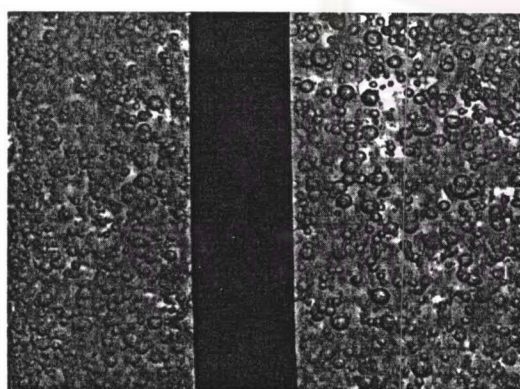
C-7 Sea water 30 ppt in A_d/A_r 2.61



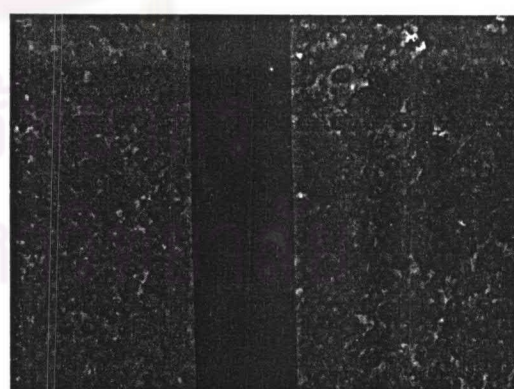
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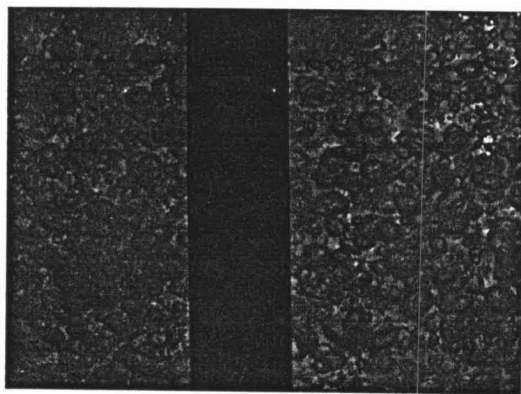
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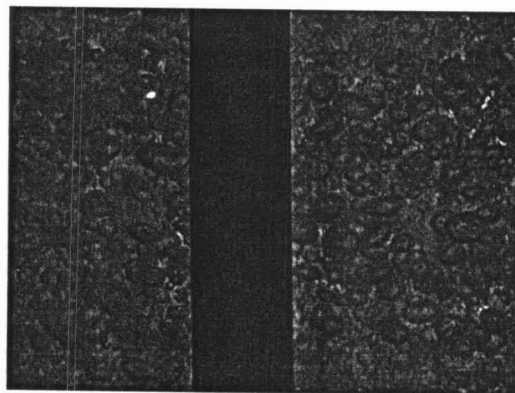
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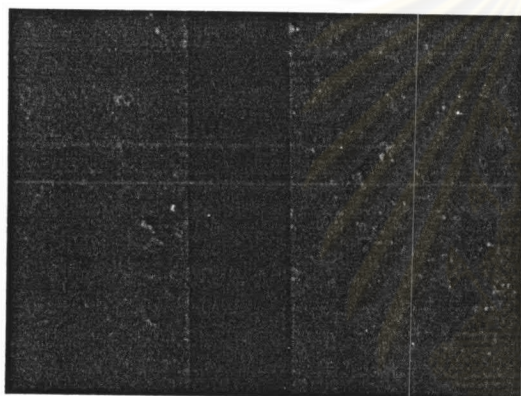
d) Superficial gas velocity 8.0 cm/s



e) Superficial gas velocity 10.3 cm/s

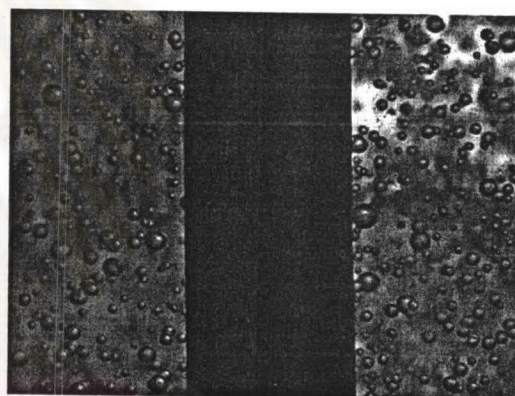


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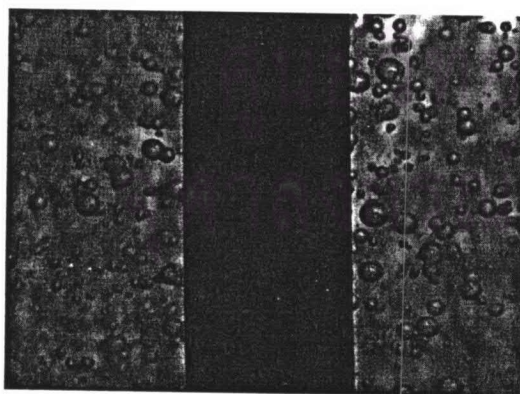


g) Superficial gas velocity 15.5 cm/s

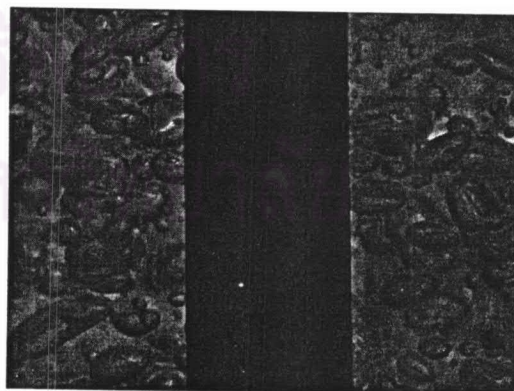
C-8 Sea water 45 ppt in A_d/A_r 2.61



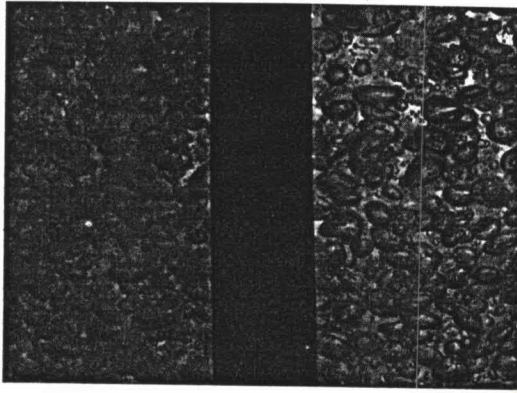
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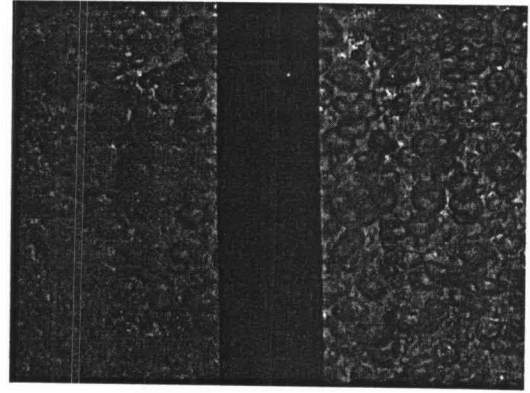
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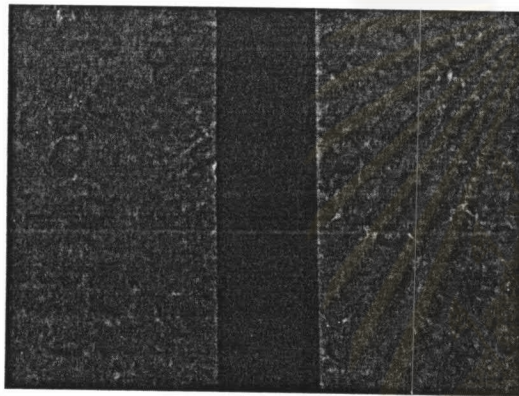
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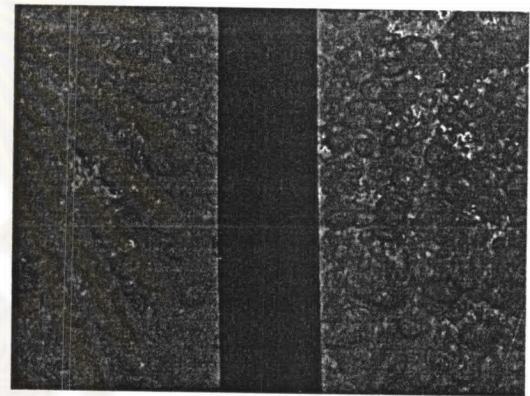
d) Superficial gas velocity 8.0 cm/s



e) Superficial gas velocity 10.3 cm/s

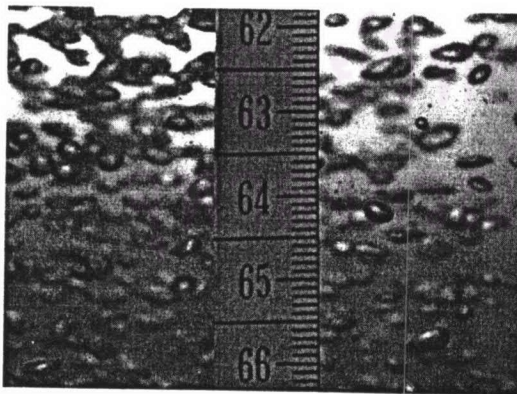


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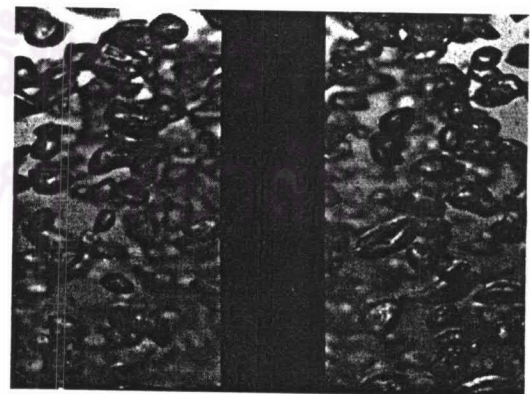


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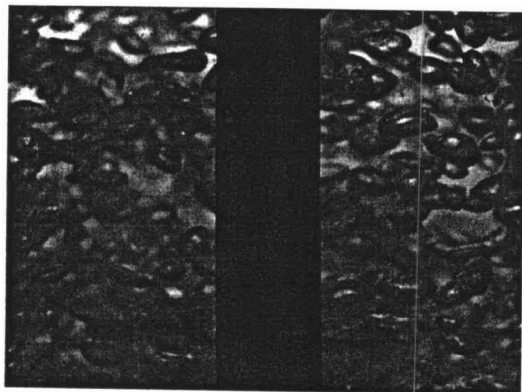
C-9 Water in A_d/A_r 1.79



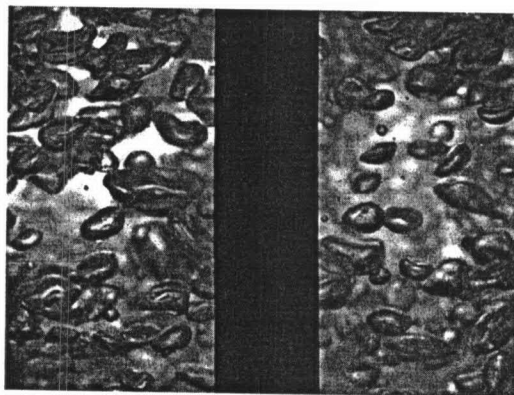
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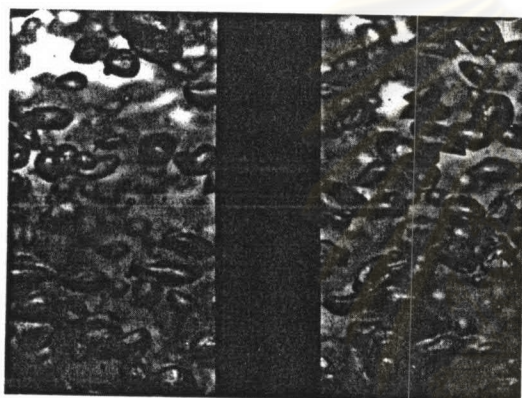
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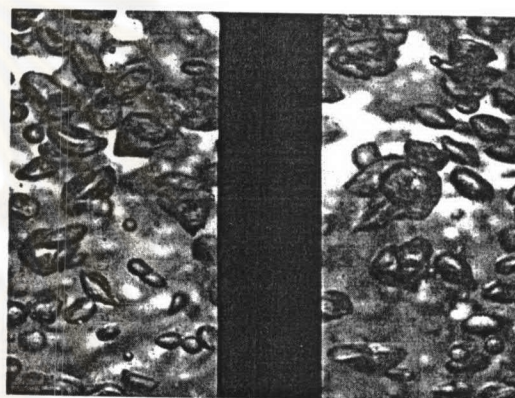
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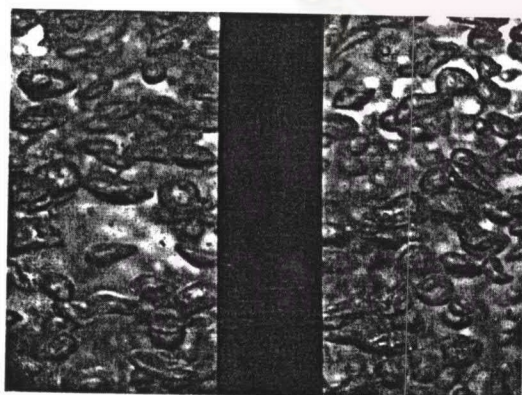
d) Superficial gas velocity 6.2 cm/s



e) Superficial gas velocity 8.0 cm/s

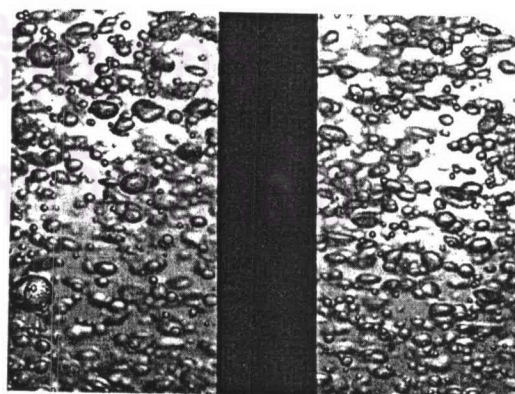


f) Superficial gas velocity 9.6 cm/s

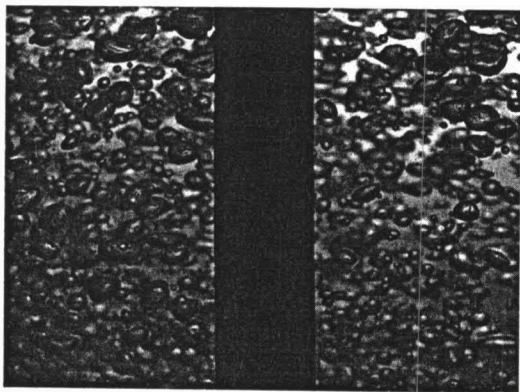


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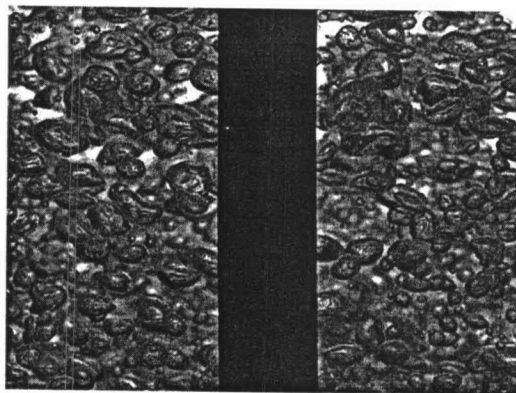
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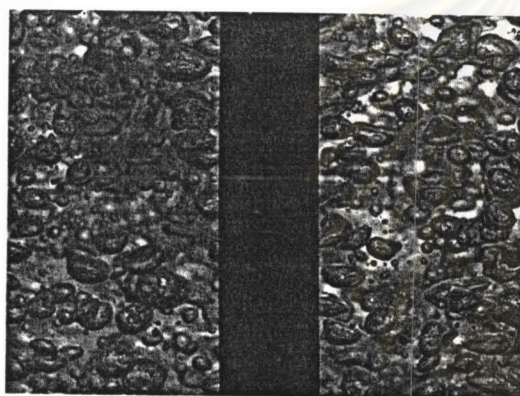
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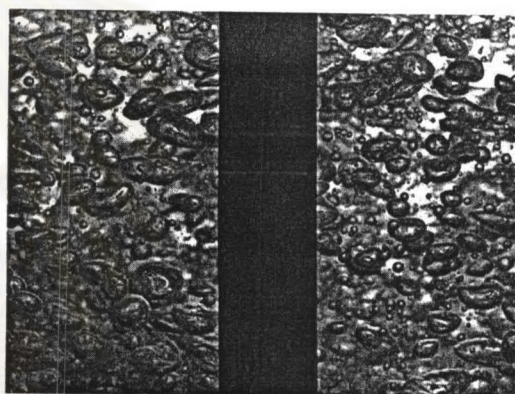
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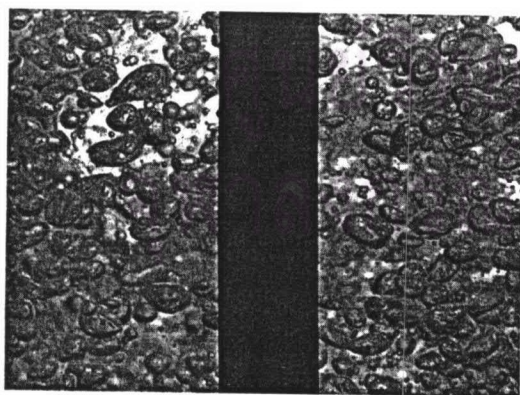
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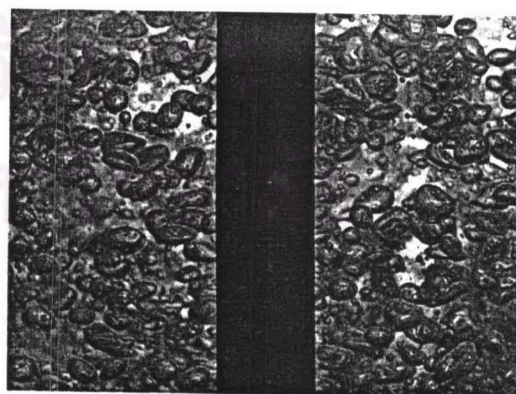
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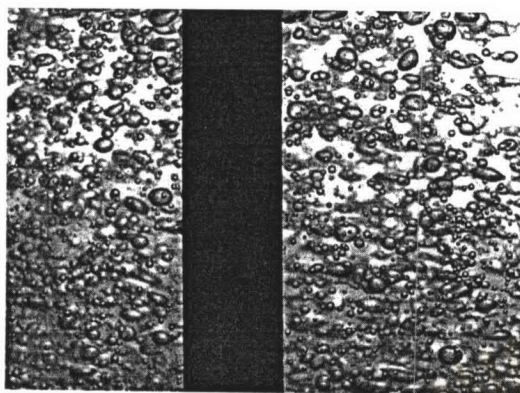


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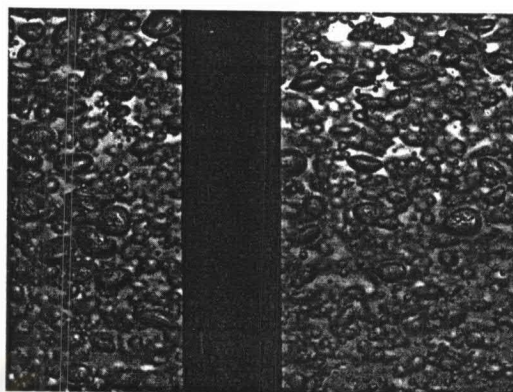


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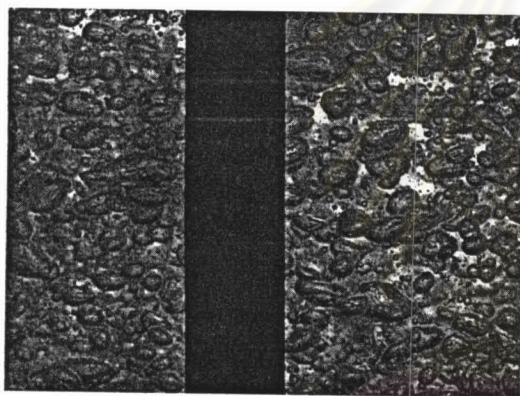
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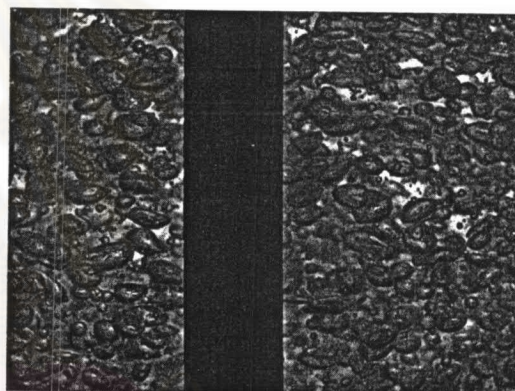
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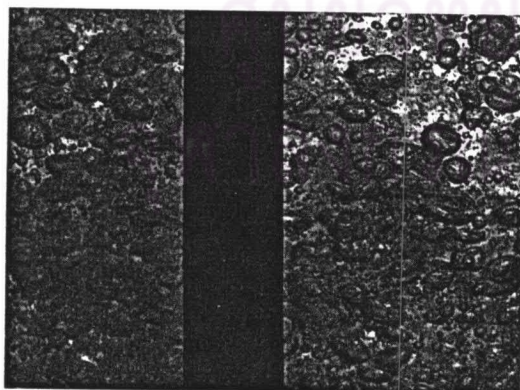
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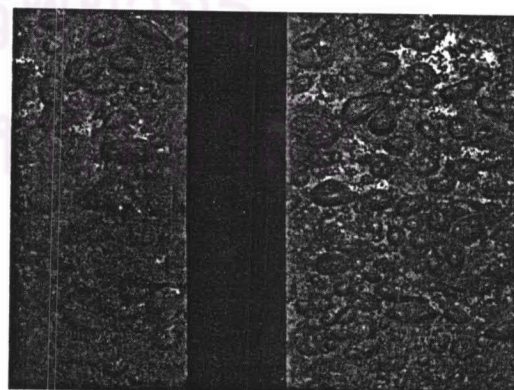
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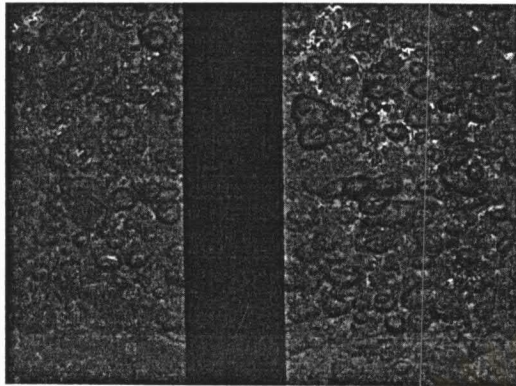
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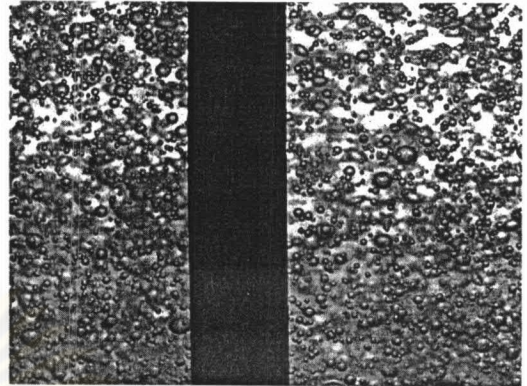
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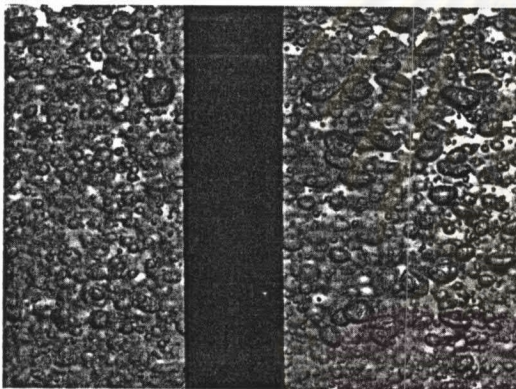
f) Superficial gas velocity 9.6 cm/s



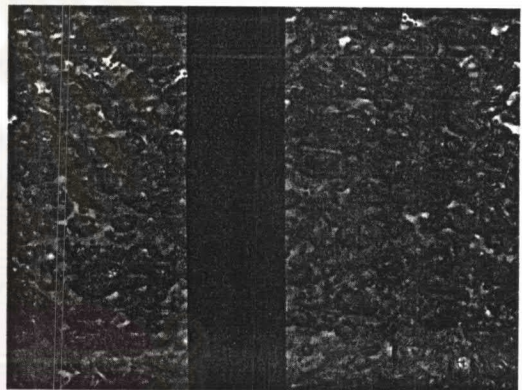
g) Superficial gas velocity 12.0 cm/s

C-12 Sea water 45 ppt in A_d/A_r 1.79

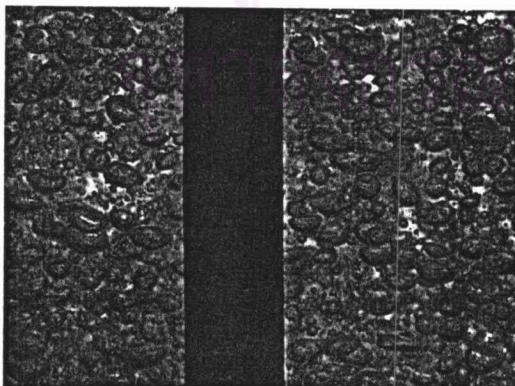
a) Superficial gas velocity 2.1 cm/s



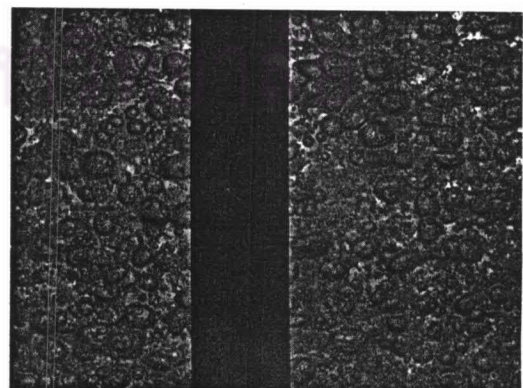
b) Superficial gas velocity 3.1 cm/s



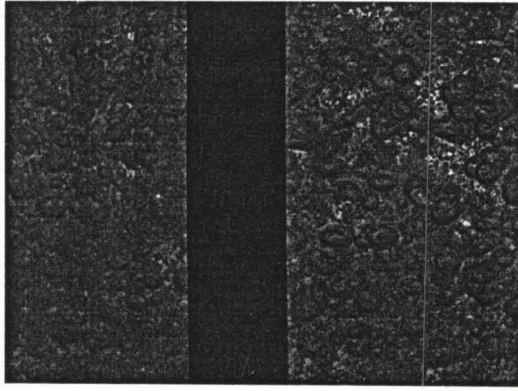
c) Superficial gas velocity 4.7 cm/s



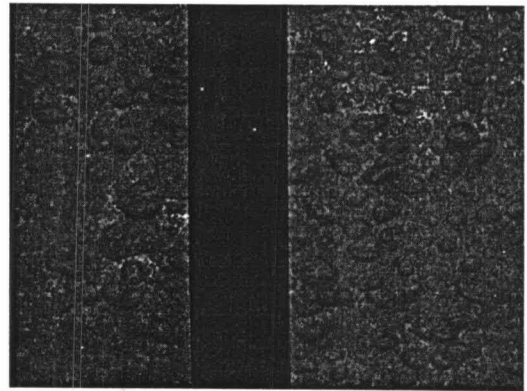
d) Superficial gas velocity 6.2 cm/s



e) Superficial gas velocity 8.0 cm/s

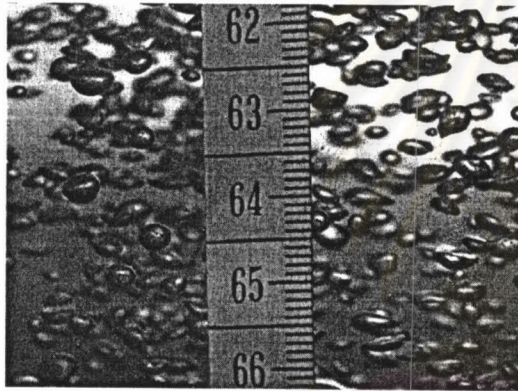


f) Superficial gas velocity 9.6 cm/s

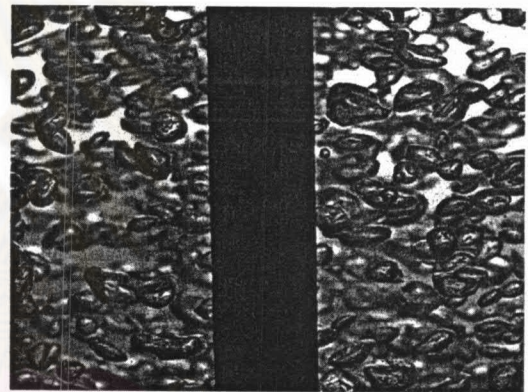


g) Superficial gas velocity 12.0 cm/s

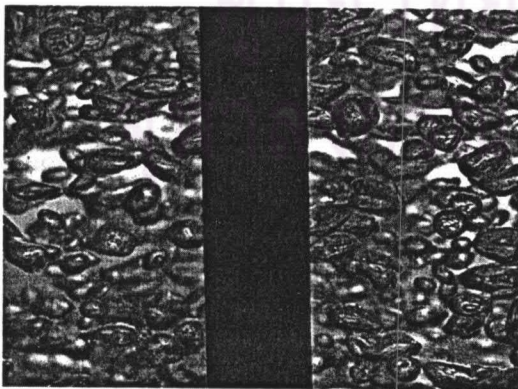
C-13 Water in A_d/A_r 1.21



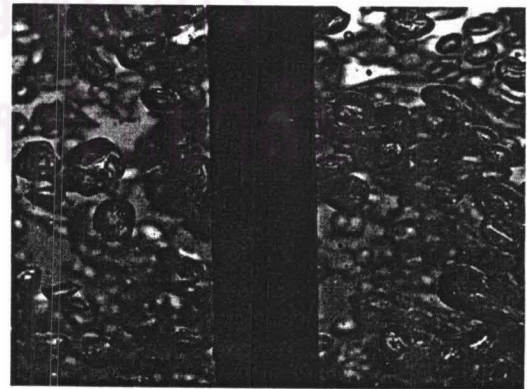
a) Superficial gas velocity 1.7 cm/s



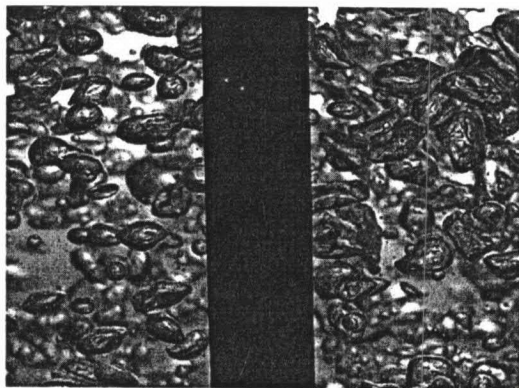
b) Superficial gas velocity 2.5 cm/s



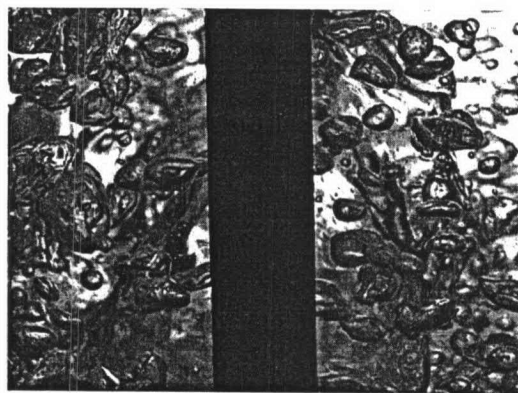
c) Superficial gas velocity 3.7 cm/s



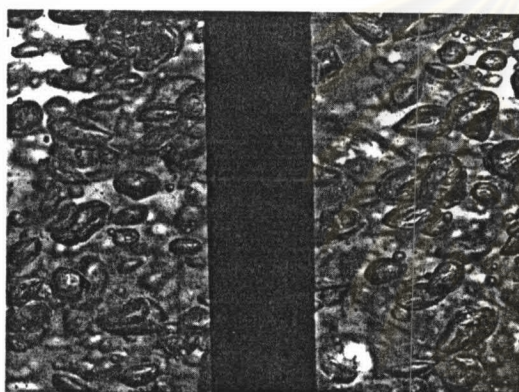
d) Superficial gas velocity 5.0 cm/s



e) Superficial gas velocity 6.4 cm/s

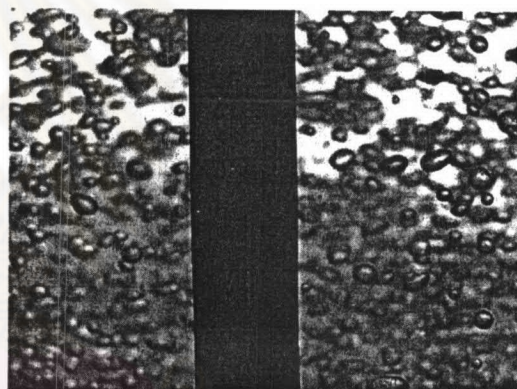


f) Superficial gas velocity 7.7 cm/s

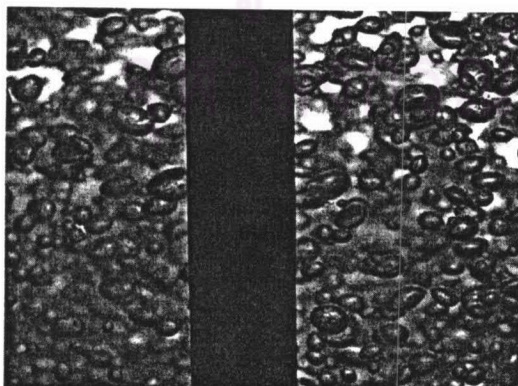


g) Superficial gas velocity 9.6 cm/s

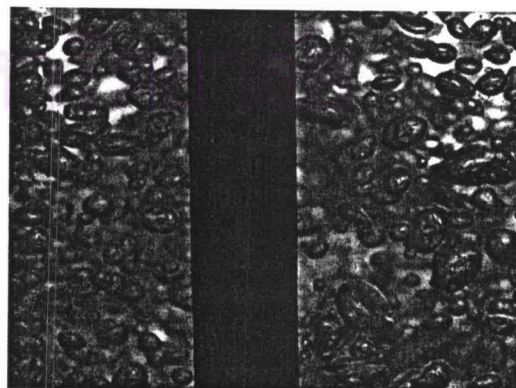
C-14 Sea water 15 ppt in A_d/A_r 1.21



a) Superficial gas velocity 1.7 cm/s

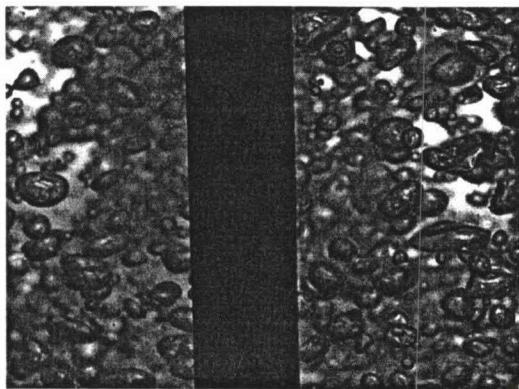


b) Superficial gas velocity 2.5 cm/s

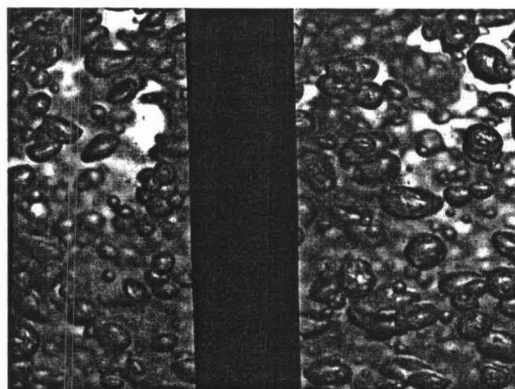


c) Superficial gas velocity 3.7 cm/s

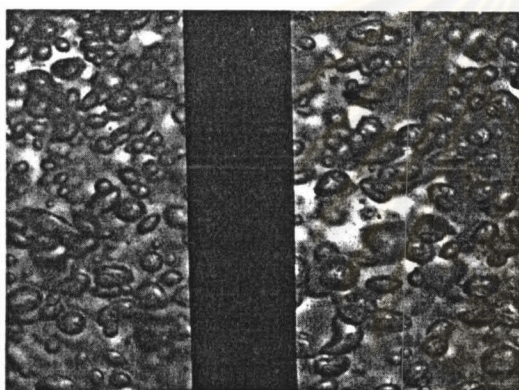
ศูนย์วิทยทรัพยากร



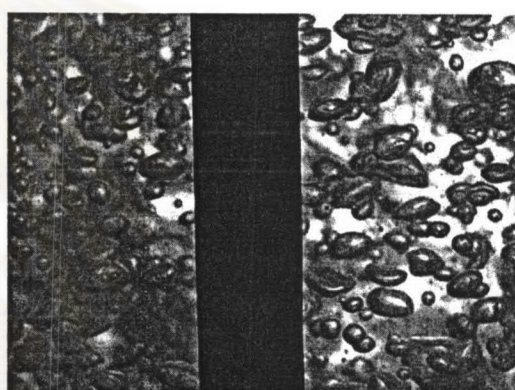
d) Superficial gas velocity 5.0 cm/s



e) Superficial gas velocity 6.4 cm/s

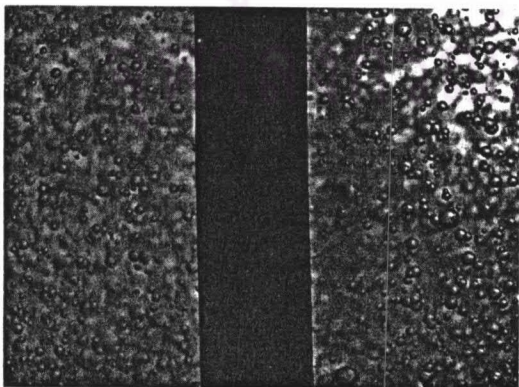


f) Superficial gas velocity 7.7 cm/s

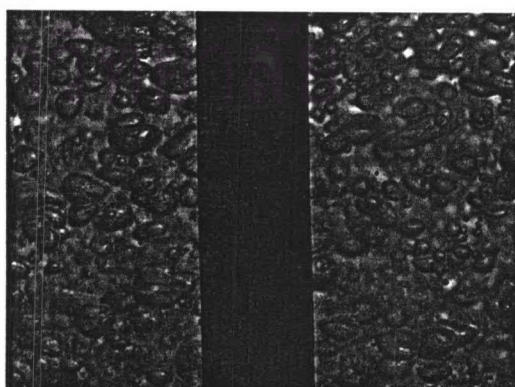


g) Superficial gas velocity 9.6 cm/s

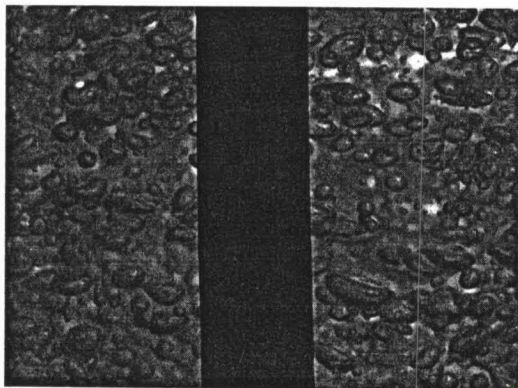
C-15 Sea water 30 ppt in A_d/A_r 1.21



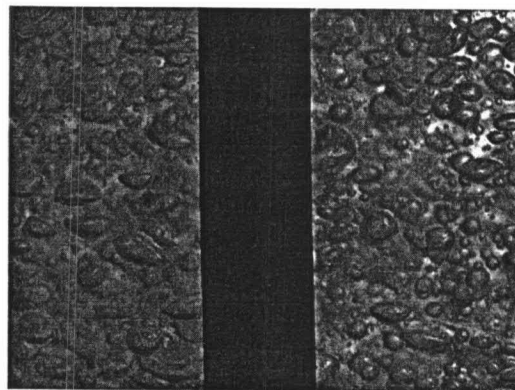
a) Superficial gas velocity 1.7 cm/s



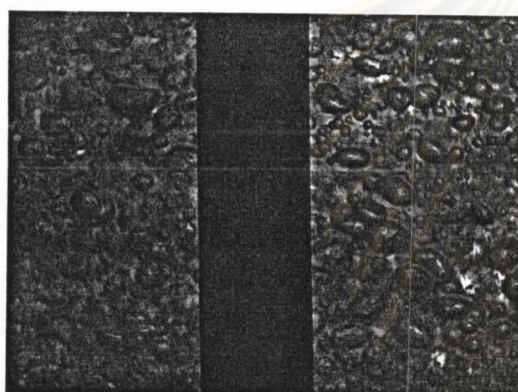
b) Superficial gas velocity 2.5 cm/s



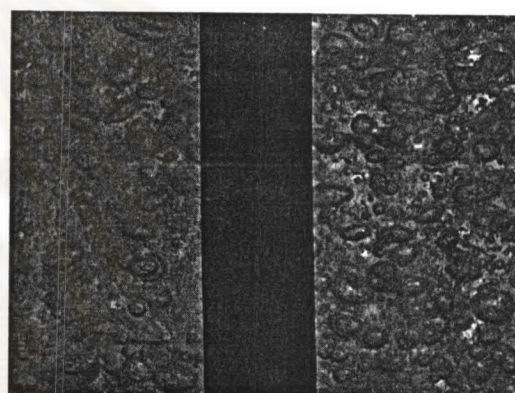
c) Superficial gas velocity 3.7 cm/s



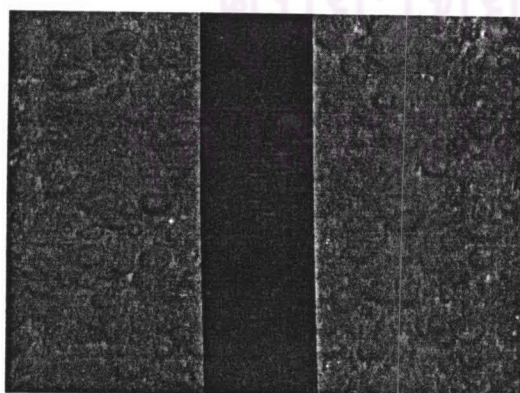
d) Superficial gas velocity 5.0 cm/s



e) Superficial gas velocity 6.4 cm/s

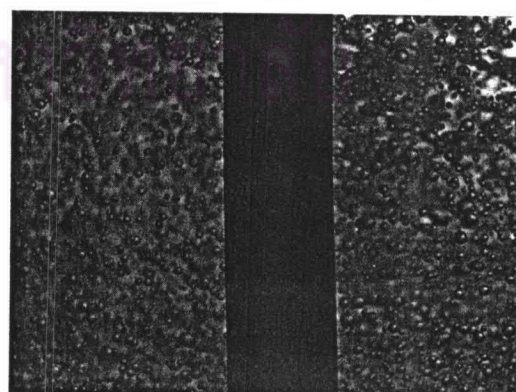


f) Superficial gas velocity 7.7 cm/s

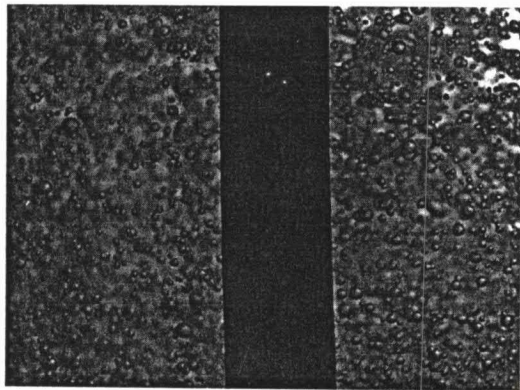


f) Superficial gas velocity 9.6 cm/s

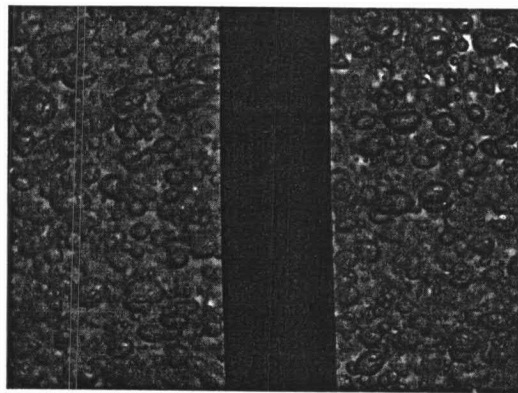
C-16 Sea water 45 ppt in A_d/A_r 1.21



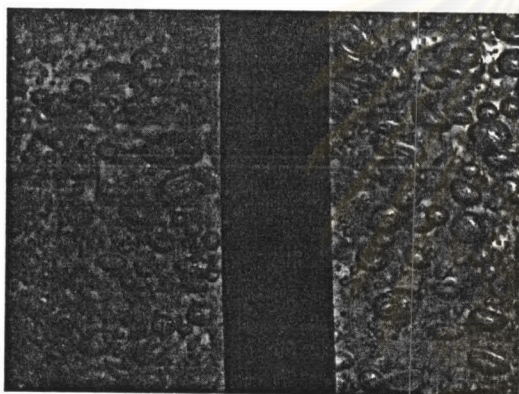
a) Superficial gas velocity 1.7 cm/s



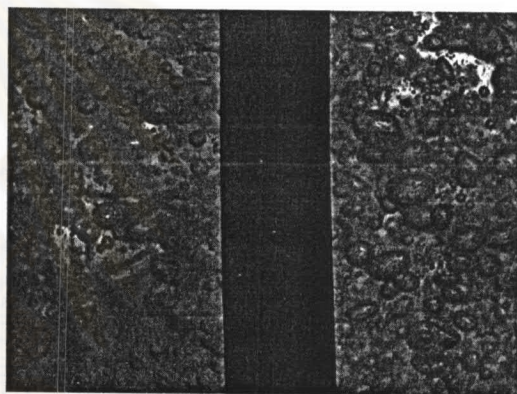
b) Superficial gas velocity 2.5 cm/s



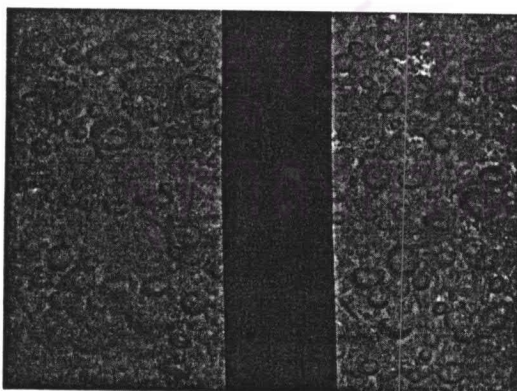
c) Superficial gas velocity 3.7 cm/s



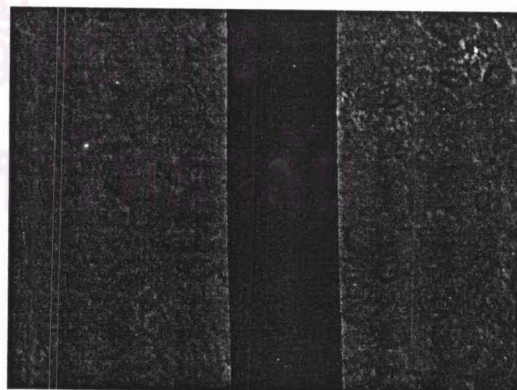
d) Superficial gas velocity 5.0 cm/s



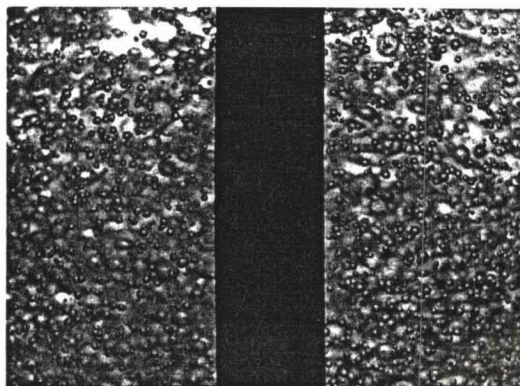
e) Superficial gas velocity 6.4 cm/s



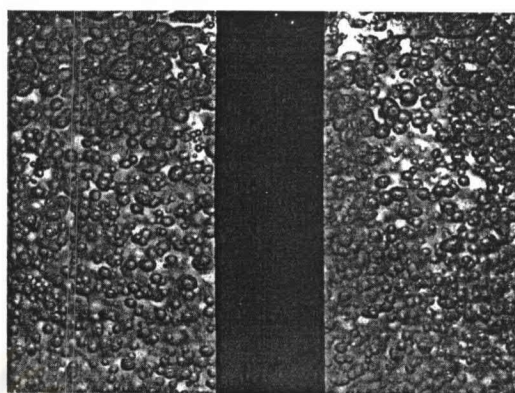
f) Superficial gas velocity 7.7 cm/s



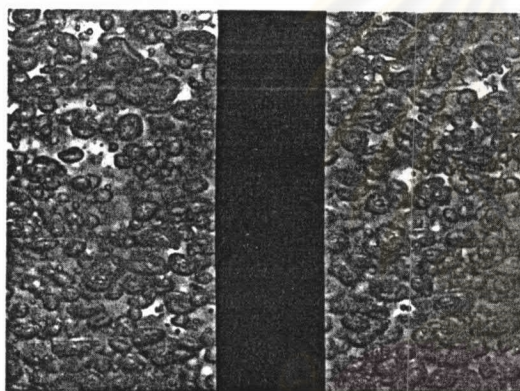
g) Superficial gas velocity 9.6 cm/s

C-17 NaCl 30 ppt in A_d/A_r 1.79

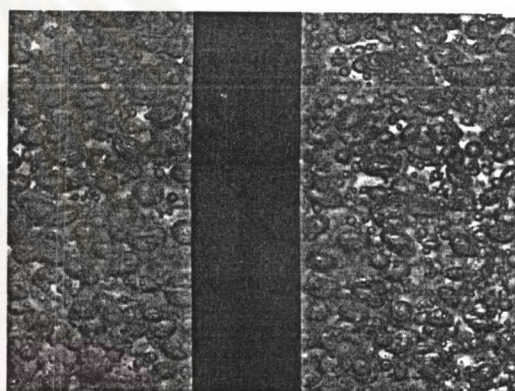
a) Superficial gas velocity 2.1 cm/s



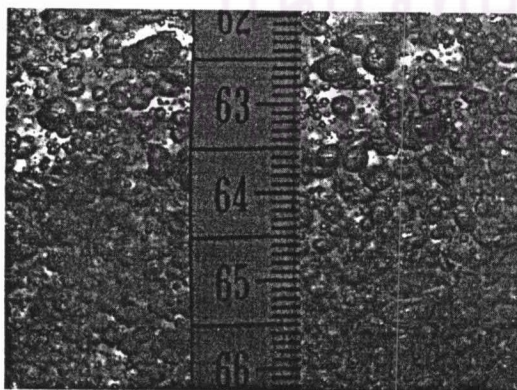
b) Superficial gas velocity 3.1 cm/s



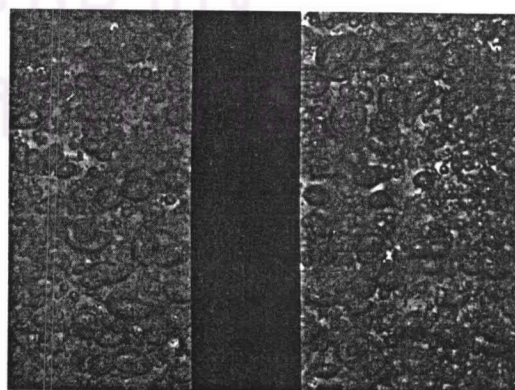
c) Superficial gas velocity 4.7 cm/s



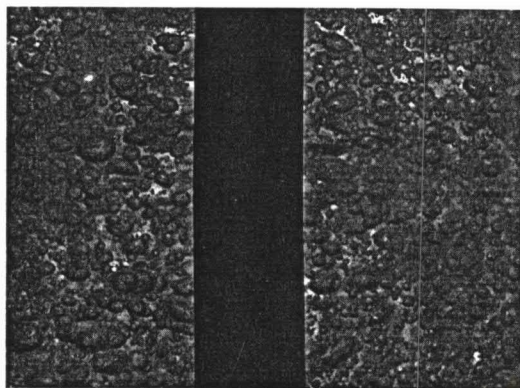
d) Superficial gas velocity 6.2 cm/s



e) Superficial gas velocity 8.0 cm/s



f) Superficial gas velocity 9.6 cm/s



g) Superficial gas velocity 12.0 cm/s



ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

BIOGRAPHY

Miss Apiradee Limpanuphap was born on April 27th, 1980 in Bangkok. She finished her secondary school from Satee Wat Rakung School in March, 1997. After that, she studied in the major of Food Technology in Faculty of Science at Chulalongkorn University. She continued her further study in Master's degree in Chemical Engineering at Chulalongkorn University. She participated in the Biochemical Engineering Laboratories and achieved her Master's degree in April, 2004.



ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย