阿伏伽德罗常数的改进与新式测量

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Amedeo Avogadro
(1776-1856)

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$N_A =$

...2140857(74) ×10²³ mol⁻¹

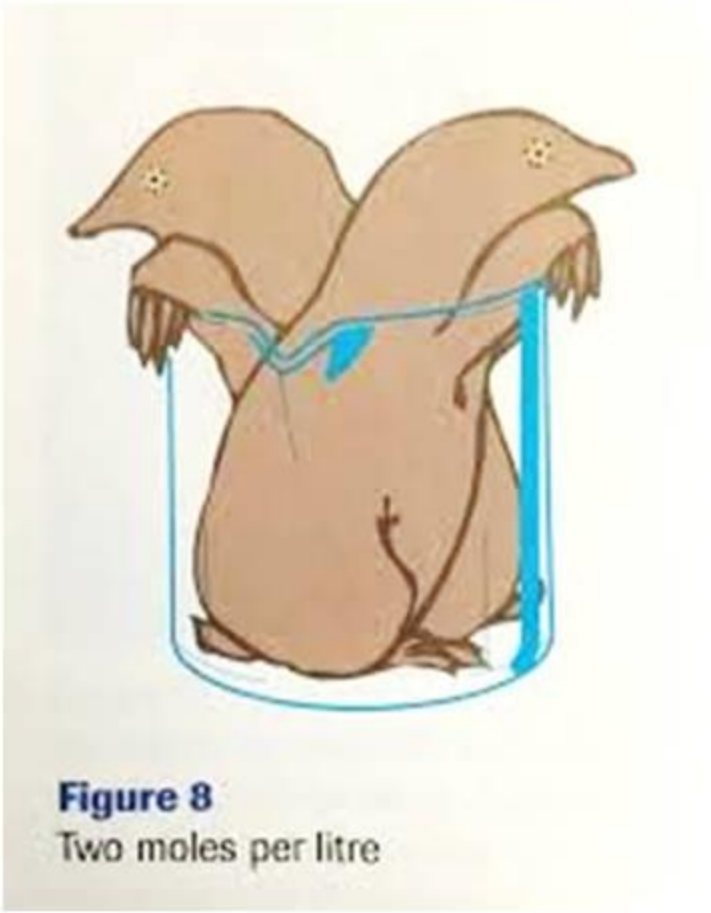

Figure 8
Two moles per litre

John Dalton
(1766-1844)

Joseph Louis Gay-Lussac
(1778-1850)

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"Constant"

- Avogadro Hypothesis

John Dalton
(1766-1844)

Joseph Louis Gay-Lussac
(1778-1850)

Joseph Loschimidt
(1721-1895)

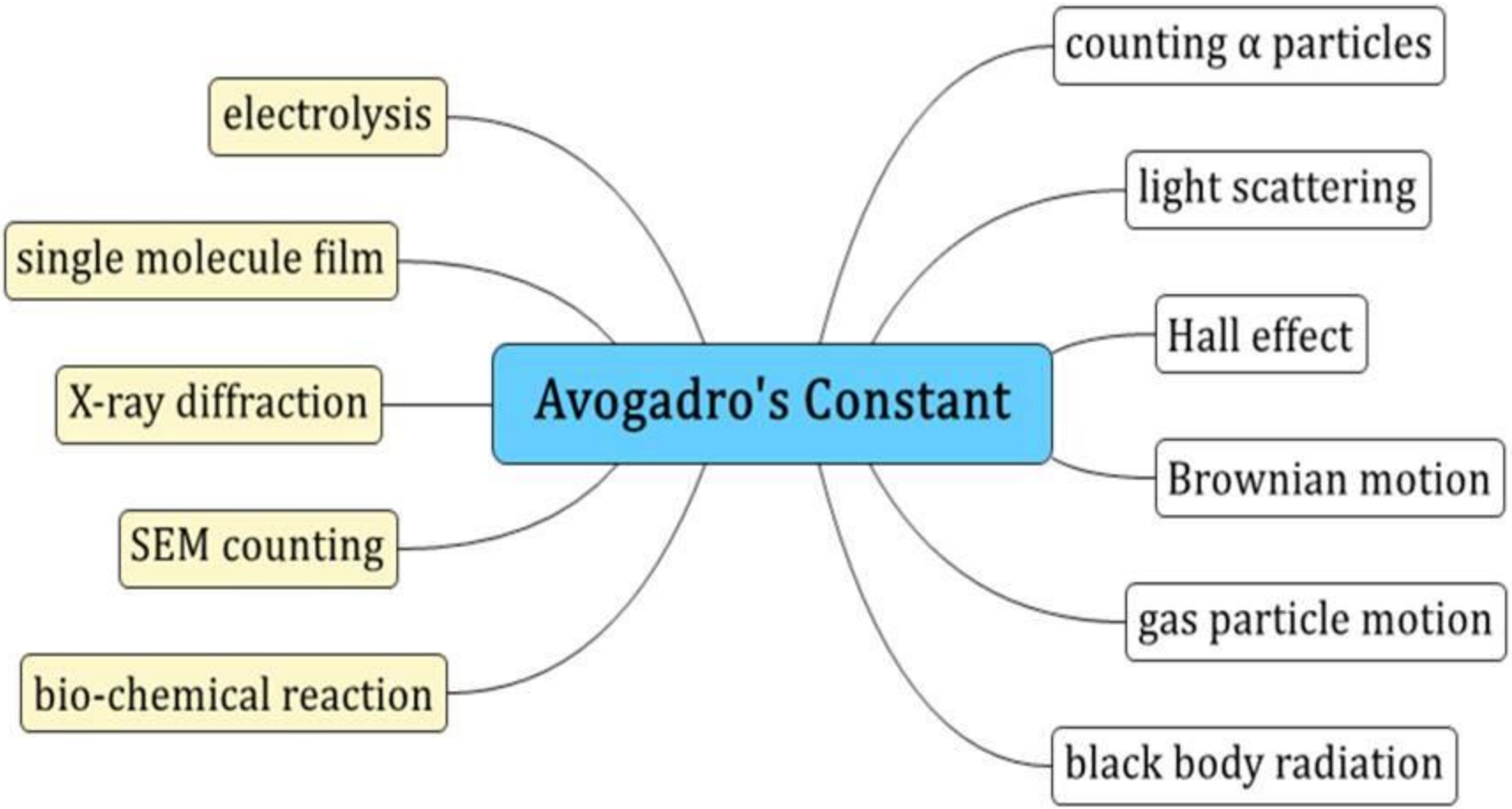
"Constant"

$1.0 \times 10^{24}\ mol^{-1}$

- Avogadro Hypothesis

Table 1 Partial values reported for N_A over the history

Year	Author	$N_A/10^{23}$
1908	Perrin	6.7
1917	Millikan	6.064
1929	Birge	6.0644
1945	Birge	6.02338
1951	DuMond	6.02544
1965	Bearden	6.022088
1973	Cohen	6.022045
1987	Deslattes	6.022134
1994	Basile	6.0221379
2001	De Bièvre	6.0221339



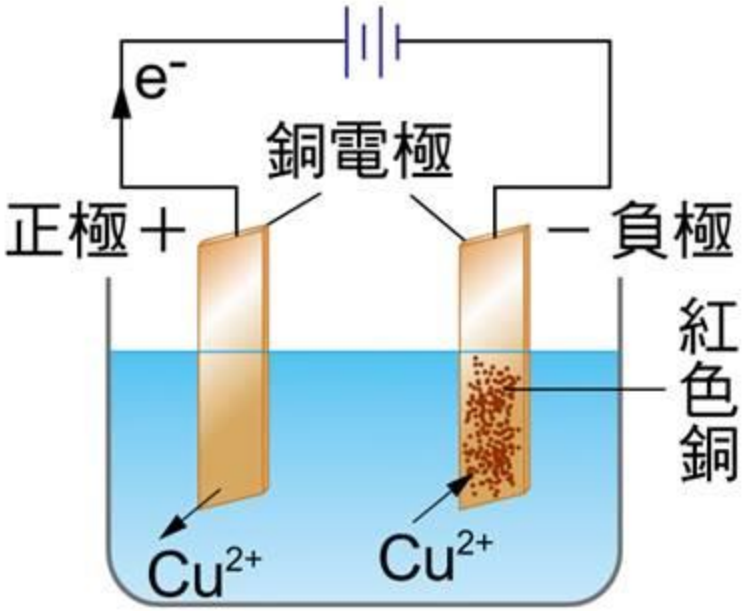
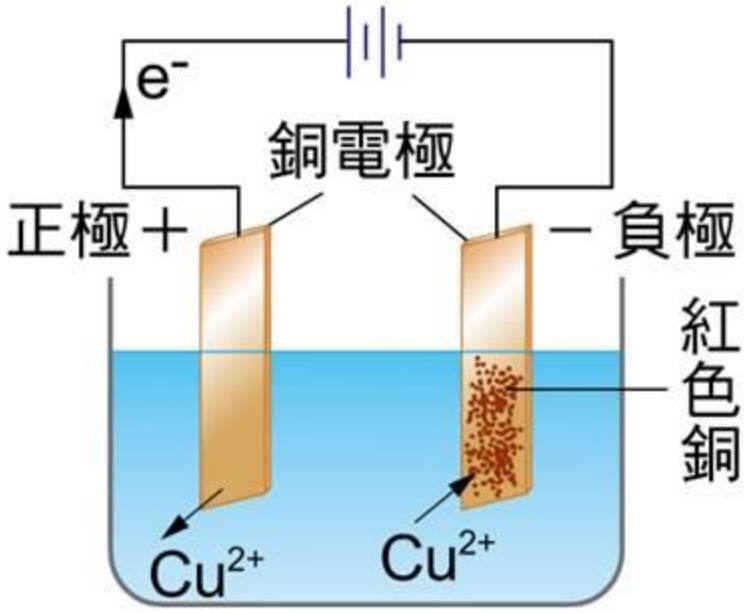


Figure 1 Illustration for electrolysis

$$Cu^{2+} + 2e^{-} \xrightarrow{electricity} Cu$$

$$Cu \xrightarrow{electricity} Cu^{2+} + 2e^{-}$$



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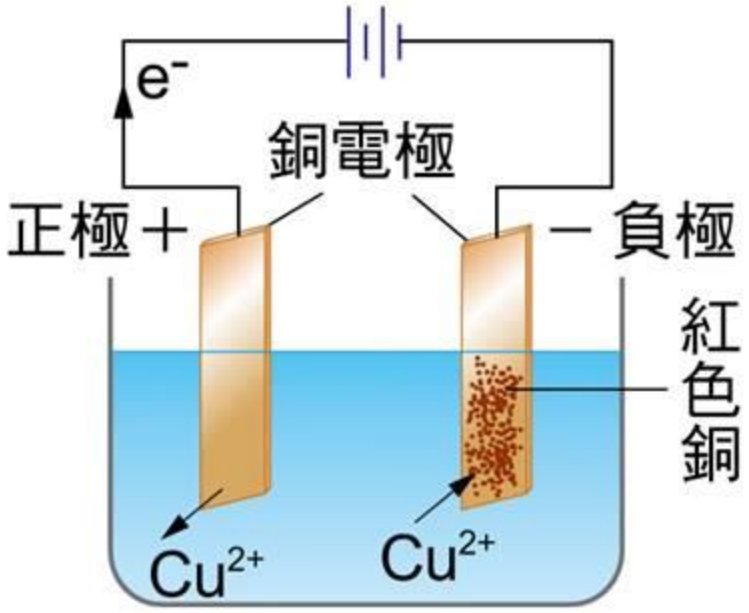
$$\begin{cases} F = N_A e \\ m = \dfrac{QM}{zF} \end{cases} \Rightarrow N_A = \frac{QM}{2me}.$$

* $M = 63.55 g \cdot mol^{-1}$
$e = 1.60218 \times 10^{-19} C$



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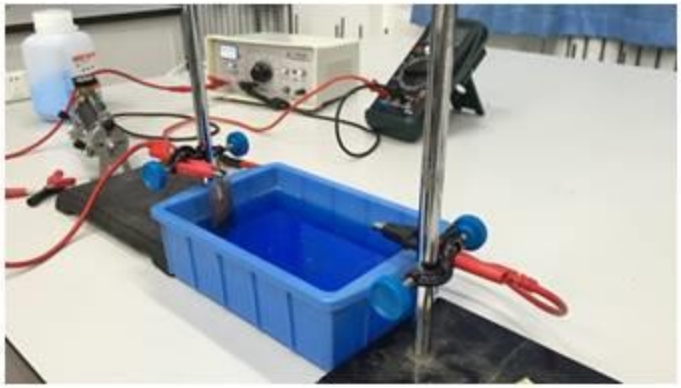
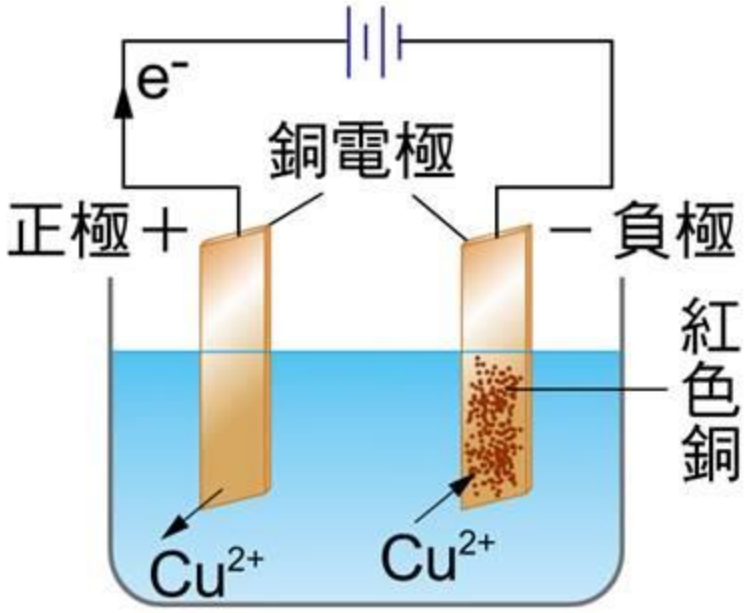
$$Q = \sum I \cdot \Delta t$$





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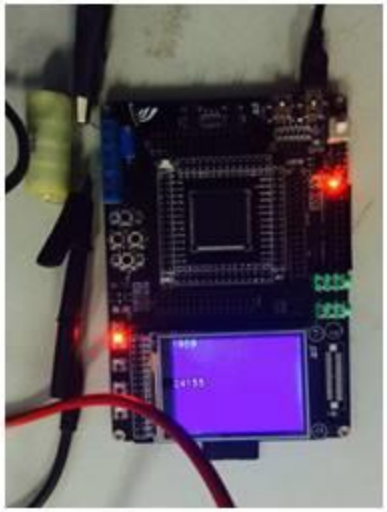
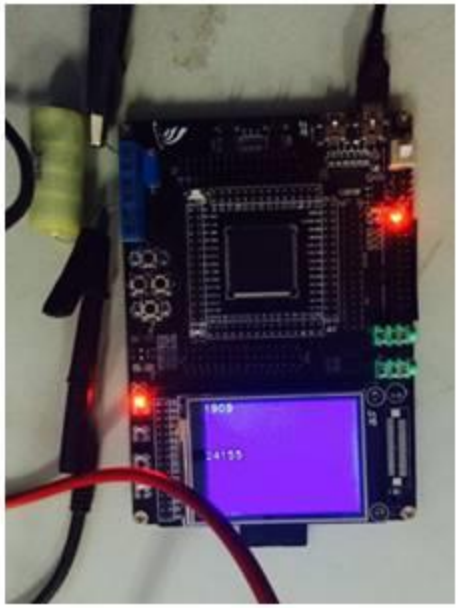
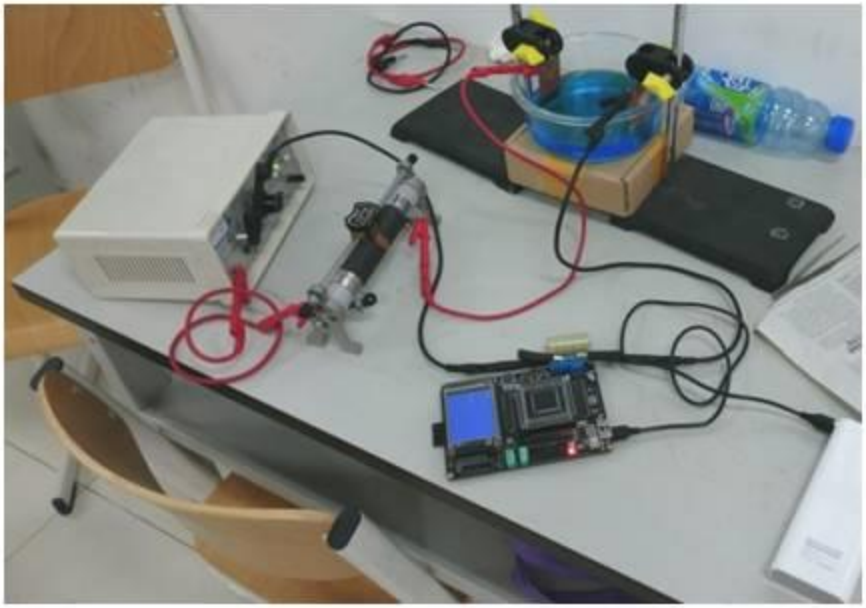






/0.1s

Figure 2 Coulomb meter

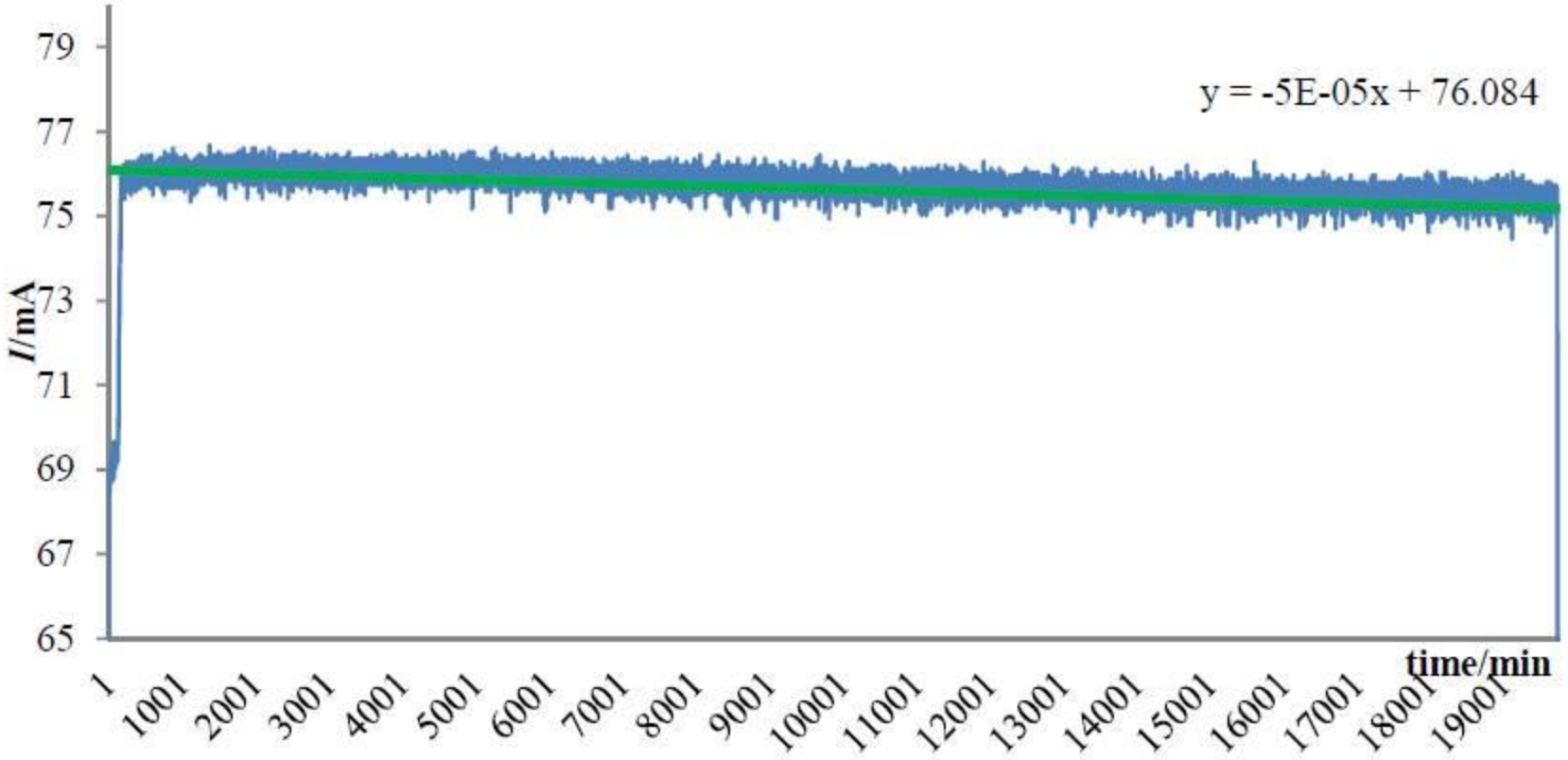
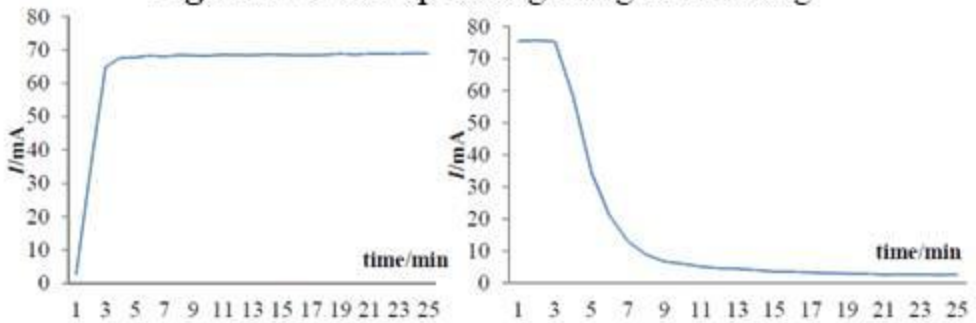
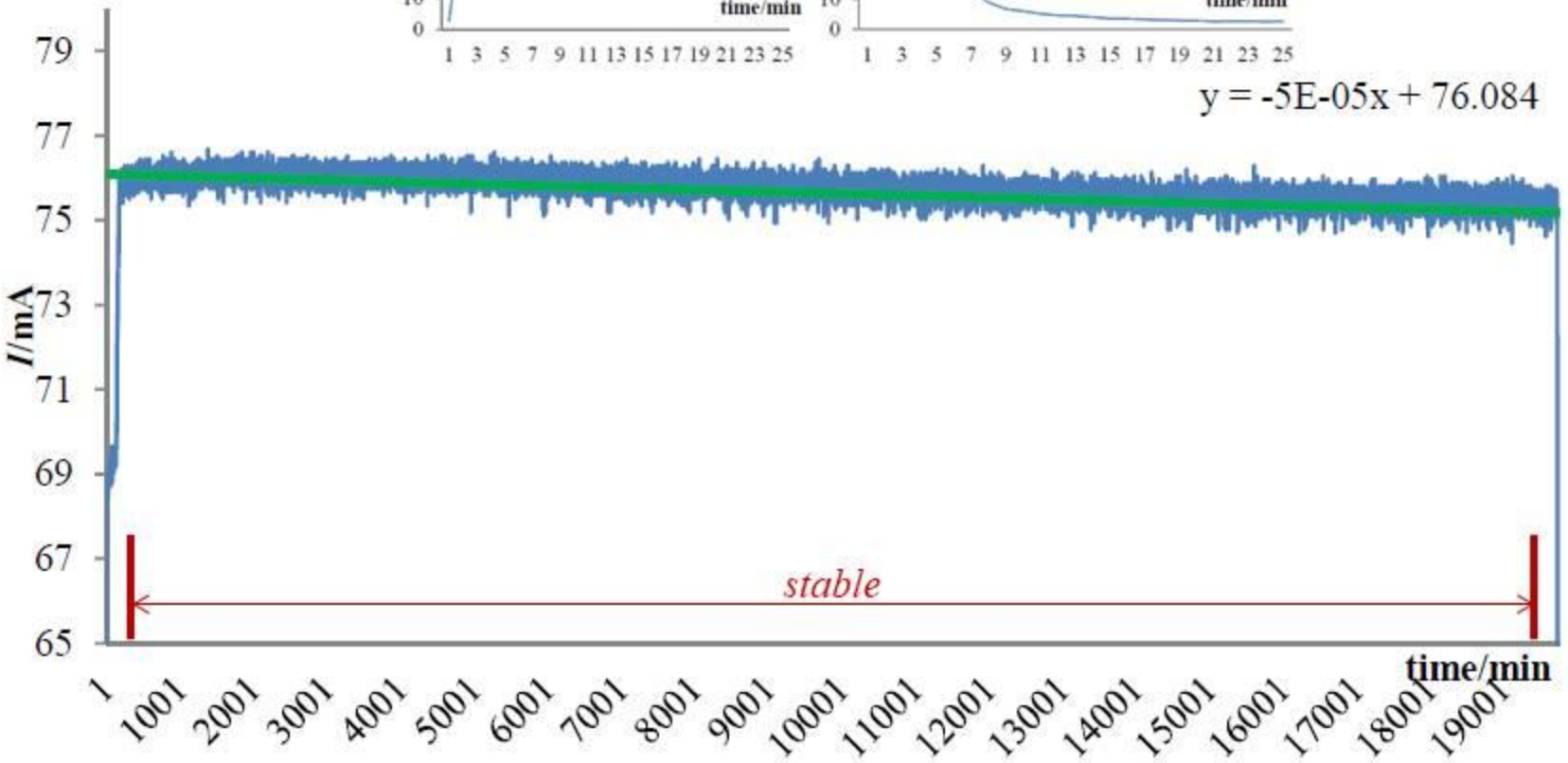


Figure 3 Recorded current intensity *I* during one 30-houe electrolysis

Figure 4 Close-up on beginning and ending





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$N_A(1)$	6.0471×10^{23}	range	$6.0317\pm0.0006\times10^{23}$
$N_A(2)$	6.0498×10^{23}	real value	6.0221×10^{23}
$N_A(3)$	6.0427×10^{23}	deviation	0.1610557%
$N_A(4)$	6.0206×10^{23}	variance	0.00216689
$N_A(5)$	5.9986×10^{23}		
$\overline{N_A}$	6.0317×10^{23}		

Table 2 Value of N_A with 5 independent electrolysis and the range, deviation and variance

Deviation: $Q \sim 0.01\%$; $m \sim 0.001\%$; $N_A \sim 0.011\%$

Notes: electrolyte - 45.000g $CuSO_4$ ~ 500.00mL H_2O

Time: pre-electrolysis > electrolysis

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阳极泥　预电解　水解反应　电极杂质　电量计发热

……

油膜法

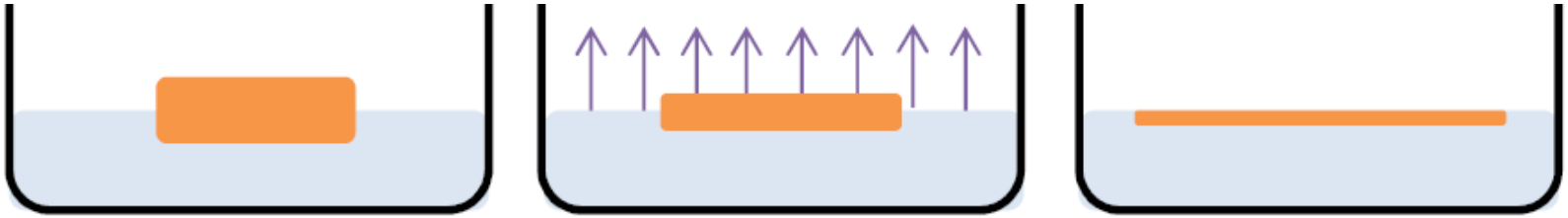


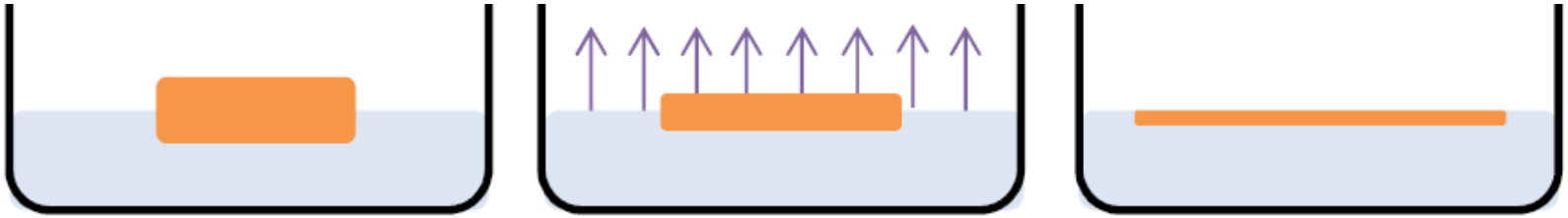
Figure 5 Above illustrates the forming of a monolayer oil film. The vaporization effect of benzene pushes the Stearic acid upwards, stretching through the whole water surface, forming a single layer.

硬脂酸 － 苯 ＋ 爽身粉

油膜法

$$N_A = \frac{M}{\frac{AV_0m}{SV}} = \frac{MSV}{AV_0m}$$

M: 硬脂酸摩尔质量
S: 单分子油膜面积
V: 苯的体积
m: 硬脂酸质量
A: 单分子油膜面积
V_0: 单分子油膜体积



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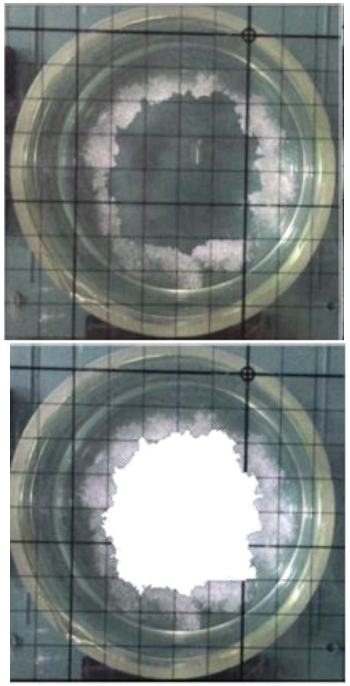

Figure 8 Pixel counting. Indicated with white powder is the basic contour of the oil film formed.

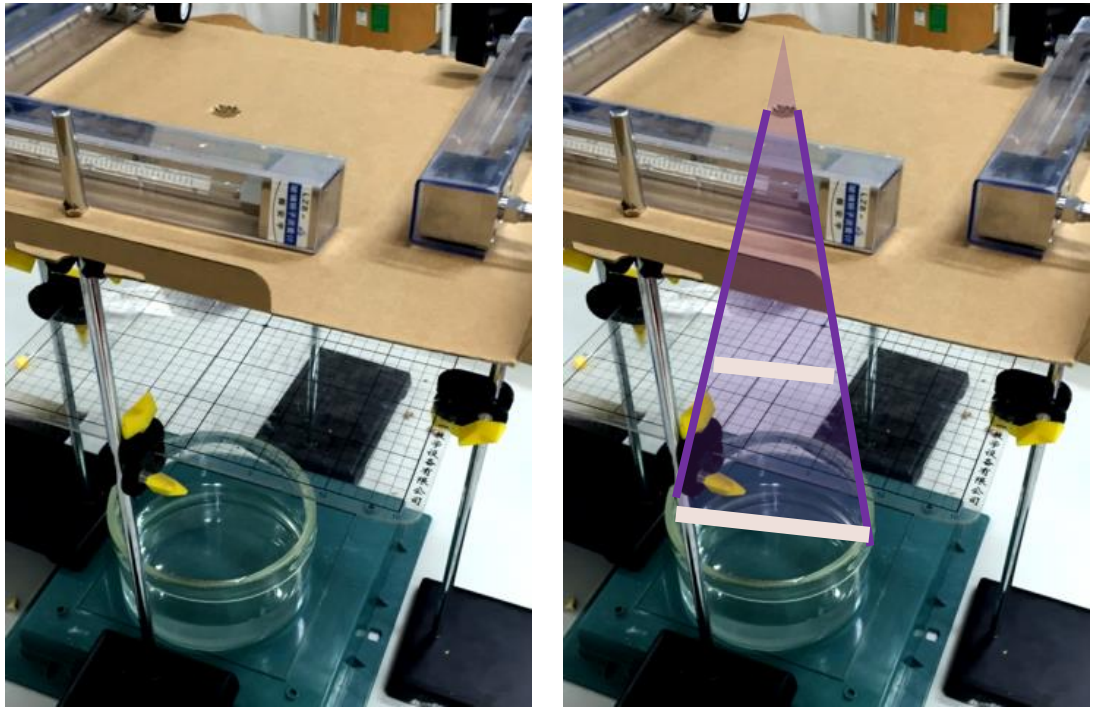

Figure 6 Improved instruments involved in the monolayer oil film

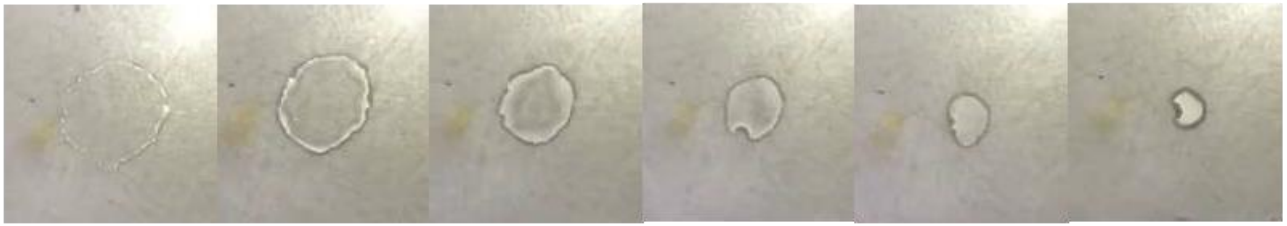

Figure 7 The extension and contraction of a monolayer oil film.

Figure 9 3 typical approximation models adapted investigating the stearic acid molecule

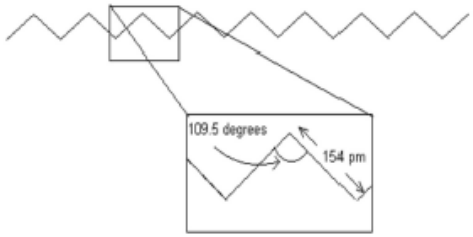

Figure 10 The illustration of a stearic acid molecule

$M = 284.49\text{g mol}^{-1}$

$S = 2.789 \times 10^{-4}\text{m}^2$

$V = 1.694 \times 10^{-8}\text{m}^3$

Ball:

$$N_A = \frac{6MS^3}{\rho\pi V^3} = 6.747 \times 10^{23}$$

Lying cylinder:

$$N_A = \frac{MS}{lm} = 1.530 \times 10^{23}$$

Standing cylinder:

$$N_A = \frac{4MS}{\pi d^2 \rho V} = 1.355 \times 10^{23}$$

胰岛素- 乙醇

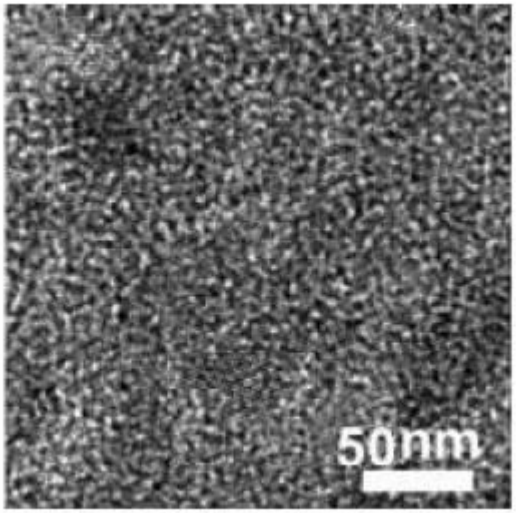

Figure 6 A picture taken during the SEM counting

$$N_A = \frac{nM}{m}$$ M: 胰岛素酸摩尔质量

$$N_A = 6.0237 \times 10^{23},\ deviation = 0.026\%$$

SEM 计数 > 电解法 > 单分子油膜.

- ✓ 电解法
- ✓ 单分子油膜

谢谢
请各位老师批评指正

Our thank goes to the high school affiliated to RENMIN University of China for providing us with the precious opportunity to conduct independent researches.

Our thank goes to our mentor Zilong Zhao for his continuous support and aid during the researching process.

Our thank goes to the parents who have always been extremely supportive during our researching process.

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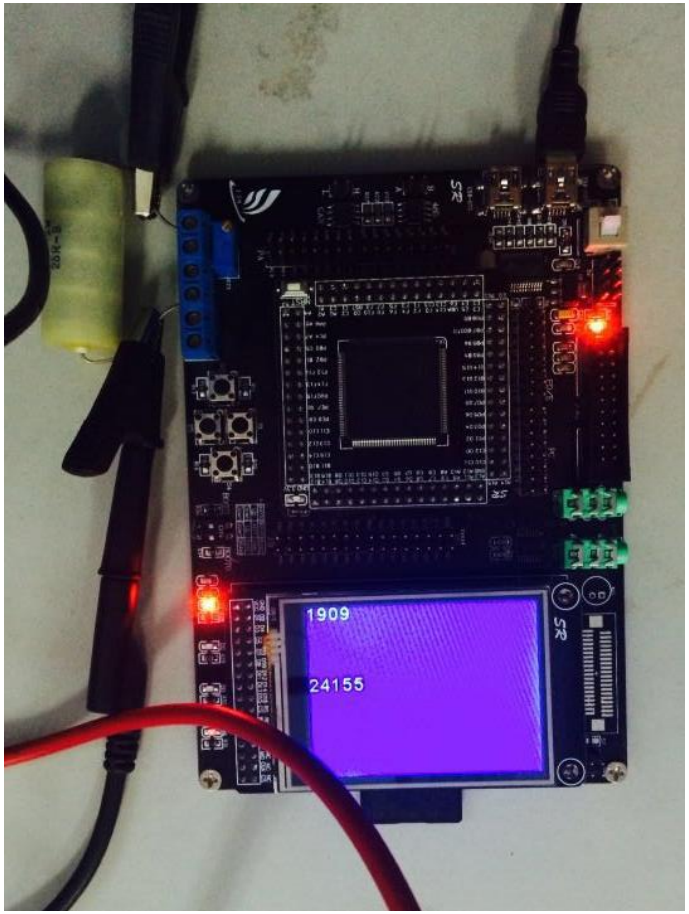
Last but not the least, our thank goes to everyone who has ever lent their helping hand to us during the process.

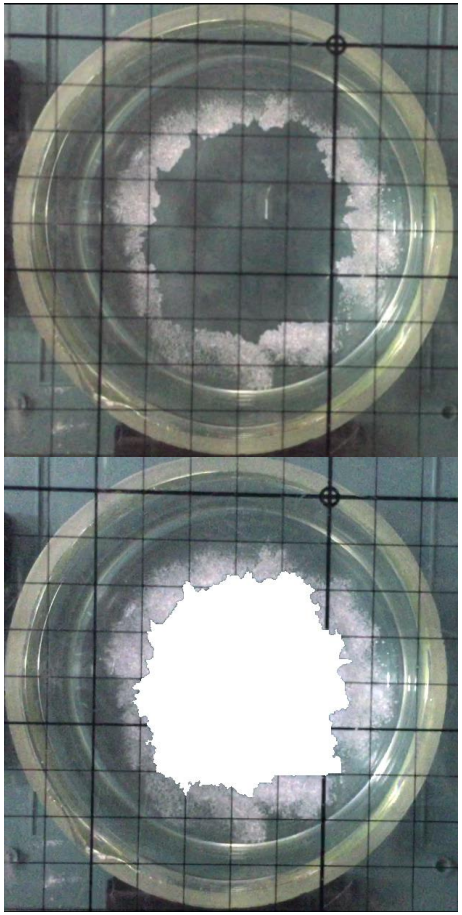
During the researching and investigation process, Wenyan Guan is mostly in charge of the electrolysis experiments, data analysis and paper writing; Zimeng Yang is mostly responsible the monolayer oil film experiment; and Shaoxun Liu is mostly responsible for the SEM counting experiment.

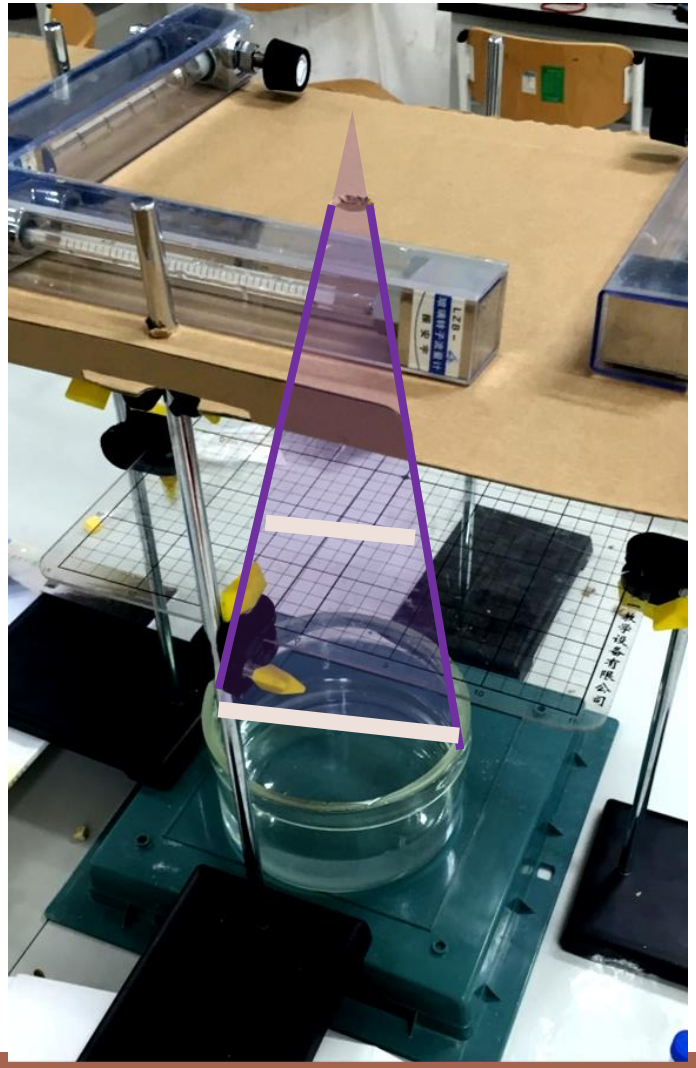
The majority of the experiments are conducted in The High School Affiliated to RENMIN University of China, during Sep.2014-Jan. 2015.

Electrolysis - AD converter



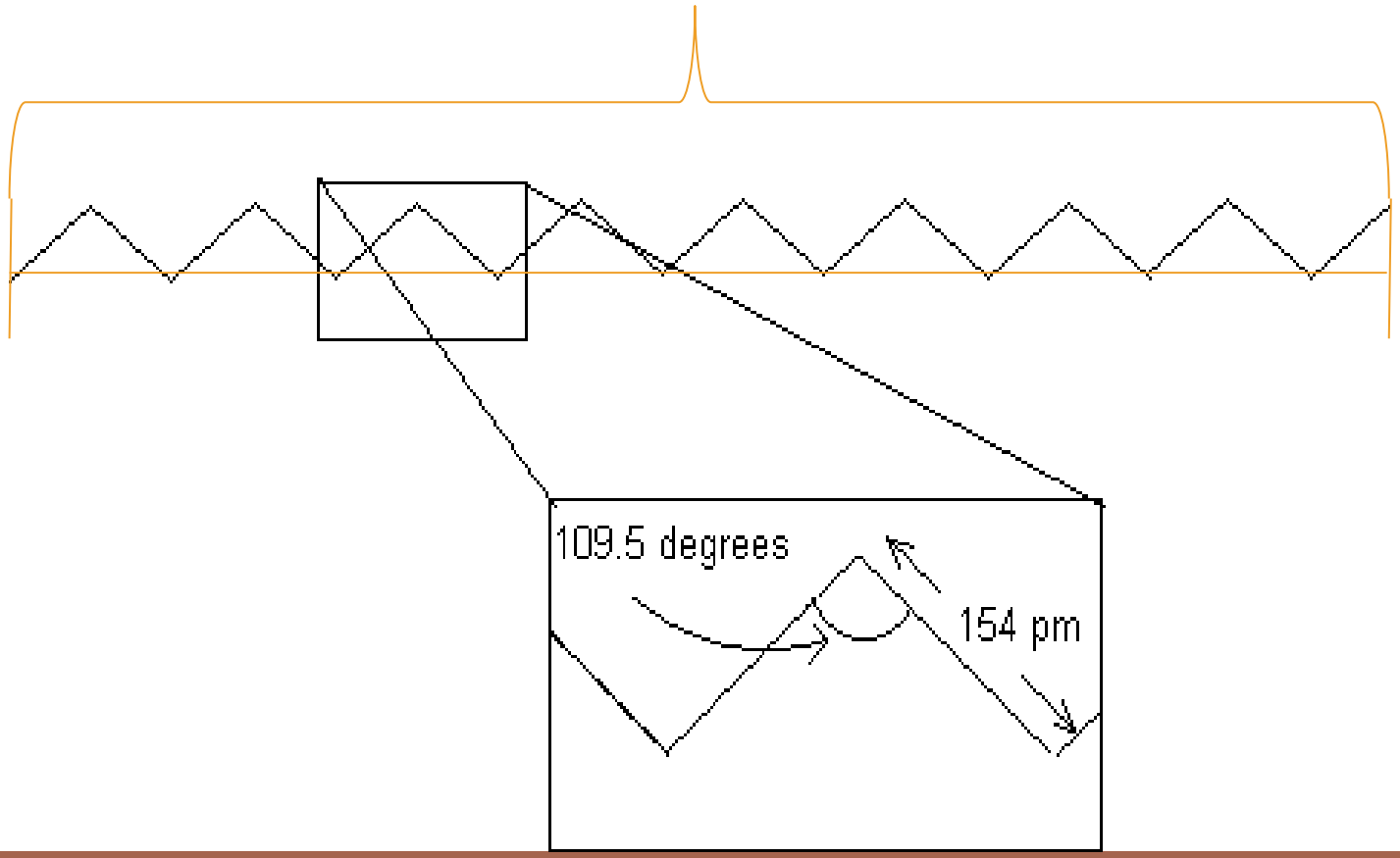
Monolayer - calculating the area



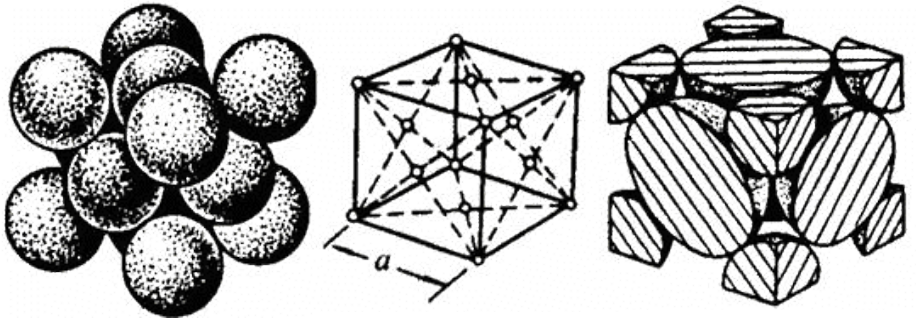


Monolayer - diameter of a single molecule

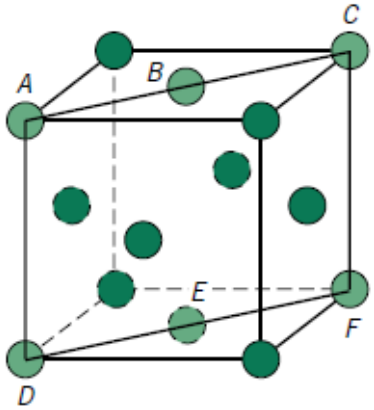
21.37967591 Å



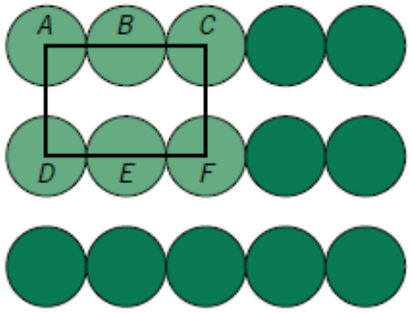
X-ray diffraction



model　　unit cell　　structure



(a)



(b)