研究简报

# 稀土对球等鞭金藻生长的影响*

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**提要**　于 1995 年 8—12 月，利用单因子实验法，首次研究了混合稀土对球等鞭金藻(*Isochrysis galbana*)生长繁殖的影响。结果表明，海水中稀土最佳浓度范围为 1.66—6.60mg / L，细胞浓度和叶绿素含量分别提高 11.6%—23.2% 和 19.9%—45.2%；混合稀土加入浓度高于 9.9mg / L 对球等鞭金藻的生长产生抑制作用。稀土对球等鞭金藻生长的促进作用与其他营养盐类浓度无关，当细胞处于指数生长期时，加入稀土效果最好。

**关键词**　稀土　球等鞭金藻　叶绿素

**学科分类号**　Q178.26

微量稀土元素对淡水生物有促进生长、改善品质的作用(储钟稀等，1994；宋振东等，1992)。天然海水中稀土元素属超痕量水平，仅为 0.01μg / L(Elderfleld *et al*, 1982)。稀土对海洋生物的影响迄今未见报道。本项目旨在探索稀土对海洋生物的作用，为进一步研究稀土在海水养殖中的应用提供基础数据。

## 1　实验材料与方法

### 1.1　实验材料及试剂

球等鞭金藻藻种为本所保存。实验用海水取自青岛麦岛近海，盐度为 30—31，pH 为 8.1。海水经沉淀、沙滤，装入聚乙稀塑料桶中备用。混合稀土为硝酸稀土，测得氧化稀土($Re_2O_3$)含量为≥38.7%(表 1)。用蒸馏水配制成 1 000mg / L 溶液。

**表1　混合稀土的成分**

Tab.1　Components of mixed rare earth

| 总量(%) | 稀土氧化物(%) | | | 杂质(%) | | | | | 放射性 |
|---|---|---|---|---|---|---|---|---|---|
| $RE_2O_3$ | $La_3O_3$ | $Ce_2O_3$ | $Nd_2O_3$ | As | Hg | Cd | Cr | Pb | (Bq/Kq) |
| ≥38.7 | 8.4 | 17.1 | 5.7 | <0.001 | <0.001 | <0.001 | <0.001 | <0.005 | <800 |

### 1.2　实验方法

**1.2.1**　培养方法　　在 250ml 三角瓶中，加适量海水，加入量根据藻种密度而定，使最终体积为 200ml，起始浓度为 80—85 × $10^4$cell / ml，营养盐浓度 N∶P∶Fe 为 30∶2∶0.5mg / L。加一定量稀土溶液，每一浓度组平行 5 个样。温度保持在 23 ± 1℃。用四只并列 40W 日光灯为光源，光照为 4 000lx(用江苏沛县测光仪器厂产 ZD-III 照度计测定)。光照时间昼：夜

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为 10∶14。每日随机调换三角瓶位置并摇动 3—4 次。每日取样计数，用 UV-365自记分光光度计(日本岛津)，在 550nm 处，用 1cm 比色皿，以海水为参比测定吸光度，通过校正曲线换算出细胞浓度。

**1.2.2** 叶绿素的测定　用 1 000ml三角瓶，以同样方法进行叶绿素实验。叶绿素测定参照《海洋调查规范》(海洋调查编辑委员会，1991)进行。

## 2 结果与讨论

### 2.1 稀土对生长速度的影响

混合稀土对球等鞭金藻生长繁殖影响的实验结果(图 1)表明，混合稀土的加入浓度为 1.65—6.60mg / L(以 La 计，下同)，与对照组比较，从第三天开始，实验组细胞浓度有所提高；从第四天开始，实验组明显($P < 0.05$)高于对照组。但加入稀土浓度高于 9.9mg / L 对

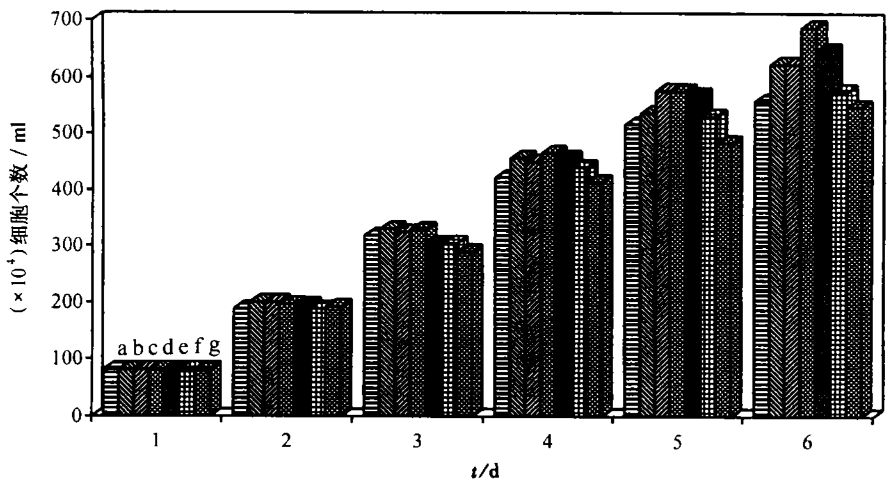


图1　稀土对球等鞭金藻生长繁殖的影响

Fig. 1　Effects of rare earth elements on the growth of *Isochrysis galbana*

混合稀土的加入浓度(mg/L)

a为0；b为1.65；c为3.3；d为4.95；e为6.6；f为8.25；g为9.9

**表2　球等鞭金藻第六天生长结果**

Tab.2　Experiment results of *Isochrysis galbana* growth on the sixth day

| 添加稀土浓度 (mg/ L) | 细胞数 ($\times 10^4$ cell/ml) | 实验组细胞数－对照组细胞数 / 对照组细胞数 |
|---|---|---|
| 0 | 558.5±7.4 | — |
| 1.65 | 623.8±5.7 | 11.6 |
| 3.30 | 623.7±2.6 | 11.6 |
| 4.95 | 688.2±9.3 | 23.2 |
| 6.60 | 648.1±3.4 | 16.1 |
| 8.25 | 575.0±9.0 | 2.9 |
| 9.90 | 548.0±4.5 | — |

球等鞭金藻的生长产生抑制作用。表 2 为第六天生长结果。从表 2 可以看出，混合稀土浓度为 4.95mg / L 的实验组细胞浓度较对照组提高 23.2%。

所用混合稀土溶液是由硝酸稀土配制而成，为证实并非由于 $NO_3$-N的引入，造成氮源增加而起的促进作用，在不同营养盐浓度下进行了实验(图 2)。结果表明，在混合稀土加入量为 4.95mg / L，营养盐浓度 N∶P∶Fe 为 30∶2∶0.5mg / L(正常量)、1 / 2 正常量、1 / 3 正常量和 1 / 4 正常量时，从第四天开始，实验组的细胞浓度明显($P < 0.05$)高于对照组。表 3 为各组培养液中氮量和第六天生长结果。当稀土加入量为 4.95mg / L 时，引入氮量为 0.64mg / L，营养盐 1 / 4 正常量中氮量为 7.25mg / L，引入稀土后其氮总量为 8.14mg / L，较对照组 1—3 的氮量低。但是，实验组 4 的细胞浓度从第五天起明显($P < 0.05$)高于对照组 1—3。说明稀土对单胞藻的生长的促进作用，并非是引入 $NO_3$-N 所起的作用。

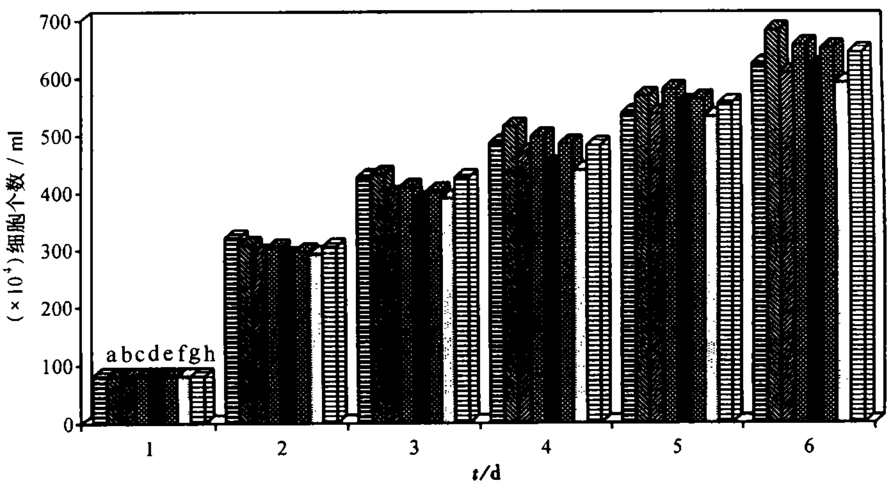


图2 不同营养盐浓度下稀土对球等鞭金藻生长的影响

Fig.2 Effects of rare earth elements on the growth of *Isochrysis galbana* at the various concentrations of nutrient salts

a为对照1；b为实验1；c为对照2；d为实验2；e为对照3；f为实验3；g为对照4；h为实验4

**表3 各组培养液中氮量和第六天生长结果**

Tab. 3 Concentrations of nitrogen for the various groups of experiment on the sixth day

| 组别 | 营养盐使用量 | 培养液中氮的总量(mg/ L) | | 细胞数($\times 10^4$ cell/ml) | |
|---|---|---|---|---|---|
| | | 对照组 | 实验组 | 对照组 | 实验组 |
| 1 | 正常量 | 30.00 | 30.64 | 624.5±9.7 | 683.5±6.7 |
| 2 | 1/ 2正常量 | 15.00 | 15.64 | 609.5±8.3 | 658.2±4.8 |
| 3 | 1/ 3正常量 | 10.00 | 10.64 | 620.6±10.2 | 651.7±9.2 |
| 4 | 1/ 4正常量 | 7.25 | 8.14 | 592.3± 7.3 | 654.0±6.5 |

混合稀土加入量为 4.95mg/ L(图 3)。以实验布置当天为第一天算起，以后依次加入稀土。实验结果表明，第一、二、三、四天加入稀土组从加入稀土后次日开始，细胞浓度明显($P < 0.05$)高于对照组，而第五天加入稀土组，则与对照组无明显差异($P < 0.05$)。从

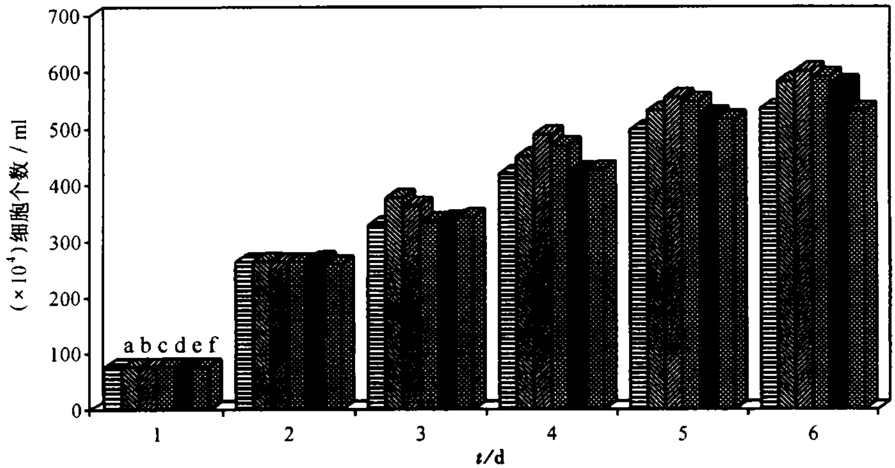


图3　稀土不同使用时间对球等鞭金藻生长的影响

Fig. 3　Effects of rare earth elements on the growth of *Isochrysis galbana* at different stages

a为对照；b为第一天；c为第二天；d为第三天；e为第四天；f为第五天

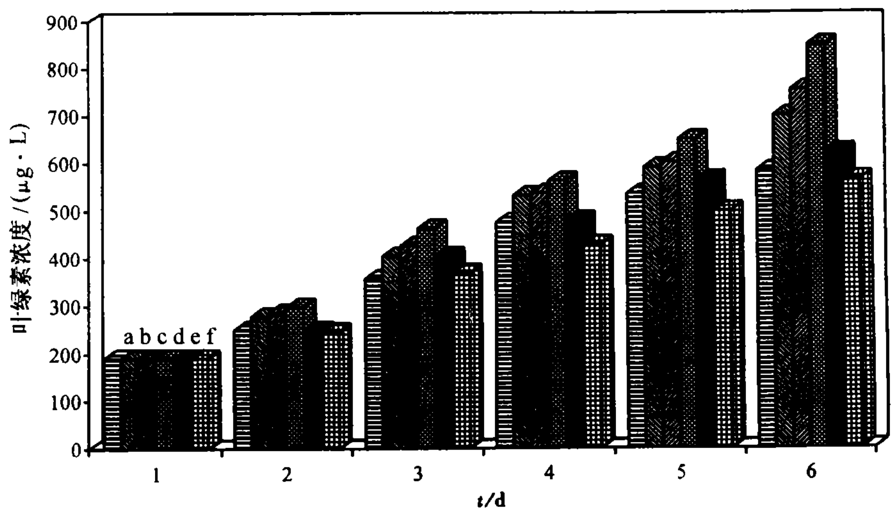


图4　稀土对球等鞭金藻叶绿素合成的影响

Fig. 4　Effects of rare earth elements on chlorophyll synthesis of *Isochrysis galbana*

a为0；b为1.65；c为3.3；d为4.95；e为6.6；f为8.25

**表4　稀土对叶绿素合成第六天影响结果**

Tab. 4　Effects of rare earth elements on chlorophyll synthesis on the sixth day

| 添加稀土浓度(mg/L) | 叶绿素含量(μg/L) | 叶绿素增长率(%) |
|---|---|---|
| 0 | 584.0 | — |
| 1.65 | 700.4 | 19.9 |
| 3.30 | 754.0 | 29.1 |
| 4.95 | 848.8 | 45.2 |
| 6.60 | 601.0 | — |
| 8.25 | 563.2 | — |

生长结果看，第一天到第四天为指数生长期。所以在单胞藻培养时，在指数生长期无论何时加入稀土，均可受到良好效果。

### 2.2 稀土对叶绿素合成的影响

稀土对叶绿素合成促进作用实验结果见图4。表4为稀土对叶绿素合成第六天影响结果。由表4可以看出，混合稀土浓度为1.65—6.60mg / L，叶绿素含量提高19.9%—45.2%。这与藻类生长实验结果相似。

## 3 结语

混合稀土元素对球等鞭金藻的生长和叶绿素的合成有明显的促进作用，这种促进作用不受其他营养盐浓度的影响。这种促进作用在细胞指数生长期内与作用时间无关。稀土对陆生生物生长繁殖、品质改善的促进作用的研究已有许多报道，并在生产上广泛应用，而稀土对海洋生物生命作用的研究则刚刚起步，尚有许多工作有待开展。

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# EFFECTS OF RARE EARTH ON GROWTH OF *ISOCHRYSIS GALBANA*

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**Abstract** In this paper, the effects of rare earth elements on the growth and chlorophyll synthesis of *Isochrysis galbana* was studied. The experimental rare earth consists of rare earth nitrate, with a $Re_2O_3$ content of≥38.7%. The method for the experiments is as follows. A proper amount of seawater and seeds of *Isochrysis galbana,* according to the concentration of *Isochrysis galbana,* was added to a 250 ml triangle flask. The experimental volume was 200 ml; the initial concentrations of the algae, 80—85($\times 10^4$ cell / ml); the concentrations of nutrient salts-N, P and Fe, 30,2,0.5 mg / L respectively. The rare earth was added then to the testing groups; 5 duplicates per concentration group were tested. The experimental temperature was 23 ± 1℃; the sourse of light, 40W fluorescent lamps; the time of light and black, 10 and 14 hours per day. The triangle flasks were shaked and exchanged their locations 3—4 times per day. The cell concentrations of the various groups were calculated by sampling and moniterring the absorption value of the algae solution through the spectrophotometric method in which the length of determinating wave was 550 nm; A 1cm colormetric utensil was used and was taken as the reference solution seawater. The chlorophyll was determined using spectrophotometry.

The results show that, firstly, the cell number of the testing groups is significantly larger ($P < 0.05$) than that of the controlled group from the fourth day and at a 1.65—6.60 mg / L concentration of the rare earth elements. The cell concentration of the testing group is raised by 23.2% at a 4.95 mg / L concentration of the rare earth elements, compared with the controlled groug. However, rare earth elements reduce the culture of *Isochrysis galbana* if the concentrations are higher than 9.9 mg / L. Secondly, the cell concentration of the testing group was significantly larger ($P < 0.05$) than that of the controlled group from the 4th day, when the ratios of nutrient salts N∶P∶Fe in the testing groups were 30∶2∶0.5 mg / L, 15∶ 1∶0.25 mg / L, 10∶0.67∶0.17 mg / L and 7.5∶0.5∶0.13 mg / L, respectively, in which the concentration of the rare earth constituents was 4.95 mg / L. Thirdly, when the rare earth was added on the 1st, 2nd , 3th and 4th day, the cell concentration of the testing groups was significantly larger ($P < 0.05$) than that of the controlled group from the second day after the rare earth was added; however, on the 5th day there was no significant different between the testing groups and controlled group. Finally, the chlorophyll content of the testing groups is raised by 19.9%—45.2% for 1.65—6.60 mg / L concentrations of the rare earth elements, compared with the controlled group.

Hence, the mixed rare earth elements have a significant effect on the enhancement of the growth and chlorophyll synthesis of *Isochrysis galbana.* There is no relationship between the enhancement effect and the concentration of other nutrient salts. Further, such an effect is not related to the time when the rare earth was added during the exponential growth period of *Isochrysis galbana.*

**Key words**　Rare earth elements　*Isochrysis galbana*　chlorophyll

**Subject classification number**　Q178.26