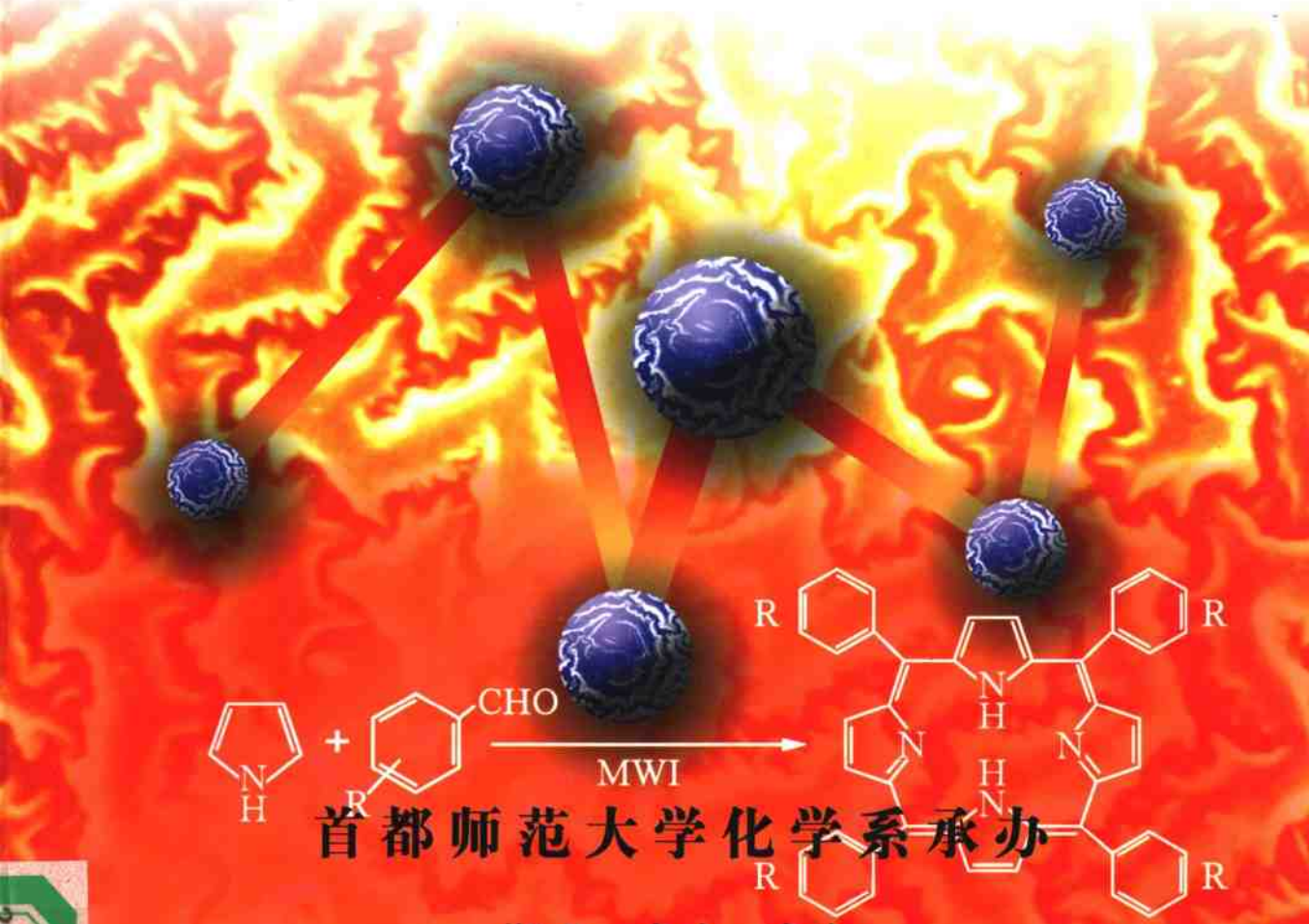
中国化学会

全国微波化学学术研讨会

论文摘要集



首都师范大学化学系承办

湖北·咸宁·咸安

2005年10月

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首都师范大学化学系　承办

湖北·咸宁·咸安

2005 年 10 月

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微波化学的发展与展望

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微波是频率在300 MHz到300 GHz范围内的电磁波，它介于电磁波谱的T赫兹波与无线电波之间。

微波技术最初是受第二次世界大战的刺激随着雷达的发展而发展起来的。后来，偶然发现它可把食物加热，导致1954年第一台市售家用微波炉的出现。

微波可直接作用于化学体系以促进或者改变各类化学反应，这就是通常意义上的微波化学，微波对凝聚态物质的化学作用主要属于这一类。微波也可先被用来诱导产生等离子体，进而实现各种可能的化学反应，微波对气态物质的化学作用主要属于这一类。这就是所谓微波等离子体化学，它是广义微波化学所涵盖的内容。

从历史上看，微波的化学应用，开始于微波等离子体化学。1952年，H. P. Broida等用微波诱导产生等离子体的办法以发射光谱法测定了氢－氘混合气体中氘同位素的含量。后来他们又将其用于氮稳定同位素的分析，从而开创了微波等离子体原子发射光谱分析的新领域。微波等离子体用于合成化学则是20世纪60年代以后的事，其中最成功的事例包括金刚石、多晶硅、氮化硼等超硬材料，有机导电膜、纳米粉体材料、兰色激光材料、单重态氧的合成；高分子材料的表面修饰和微电子材料的加工等，其中不少已形成工业化生产。

微波能的直接化学应用也开始于分析化学。1974年J. A. Hesek最先将微波炉用于样品烘干。次年，有人把微波用于生物样品的消解并取得了很大的成功。现在这一技术，包括微波辅助萃取等已经商品化并作为标准化方法被广泛应用于分析样品，特别是生物、环境和地质样品的预处理。

合成化学中应用微波能始于1986年，R. Gedye等把微波炉用于酯化、水解、氧化和亲核取代反应和R. J. Giguere等将其用于蒽与马来酸二甲酯的Diels－Alder环加成反应的研究。此后，这方面的研究发展很快，迄今已经在有机合成，特别是药物合成方面取得了长足的进步，已经证明有上百种类型的化学反应可在微波作用下被大大加速并提高产率。甚至一些靠传统加热办法无法实现的反应，在微波作用下也得到了实现。

近年来，微波在无机固相反应中的应用也已经成为一个热点领域。在陶瓷材料的烧结，固体快离子导体、超细纳米粉体材料、沸石分子筛的合成等方面都取得了许多创新结果。

在催化领域，由于微波可以透过不吸收微波的Al_2O_3，SiO_2等无机载体而直接作用于负载其上的催化剂上，将吸附其上的羟基、水、有机物分子激活，从而加速反应的进行。这方面研究最多的是甲烷合成高级烃类、光合作用的模拟和酸气污染物的去除等。

此外，微波在环境污染物的治理、冶金、石油化工、食品加工、中药现代化等与化学相关领域也都有广泛应用。可以看出，其应用已经遍及化学的几乎每一个分支。

微波化学的发展离不开微波反应设备的不断改进和更新。在早期，微波辅助化学反应几乎都是利用家用微波炉进行的。由于家用微波炉采用的是多模腔，又没有控温、控压设施，因此，往往容易出事故，而且结果也难以重复。后来，出现了可以连续调节功率，而且备

有控温、控压设施的单模聚焦微波反应系统，并且把批次式反应容器改成流动式反应容器，进一步改善了微波反应效率，促进了微波化学的迅速发展。

可以看出，现在微波化学实际上已经成为化学学科中一个十分活跃而富有创新成果的新分支学科，值得有创新精神的青年化学家予以积极关注。

但是，在微波化学的发展过程中一直存在着一个难以解开的难题：微波与物质相互作用时到底有没有非热效应？根据化学键理论，要打断分子的化学键至少需要 80 - 120 kcal/mol，而微波光子的能量只有 0.037 kcal/mol，还不及分子间作用力（Van der Waals 力）大。凭借这点能量显然不可能打断任何化学键，所以在微波作用下应该不可能发生任何所谓的“非热效应”。但是，近来的不少研究又提供了越来越多的，用简单的热效应所无法解释的例证。这显然是微波化学在今后的发展中必须面对和予以突破的重大理论和实践问题。

在合成方法方面，考虑到微波的穿透深度有限，同时考虑到反应体系尺度对于反应速率的影响及发展绿色合成的要求，显然宜着重发展流式反应系统，并力争实现闭环反应。这当然要求在微波反应系统方面做出相应的革命性改进。

微波化学仍然是化学领域中一片尚待开垦的“处女地”，有诸多原始创新的机会，热切期望我国化学界的年轻学者能够抓住机遇，迎难而上，争取做出无愧于时代的贡献！

Microwave – Assisted High – Throughput Synthesis of Compound Libraries for Catalysis and Biological Application

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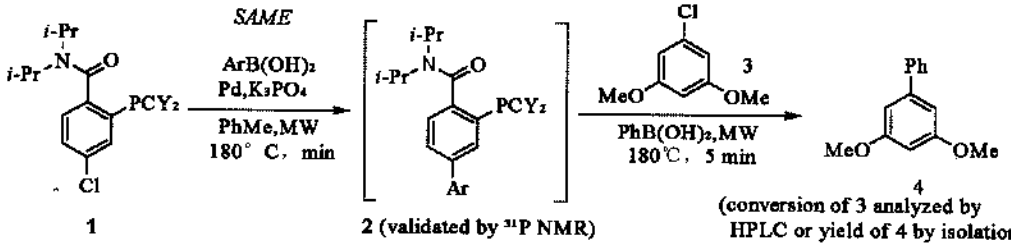
Microwave – assisted organic synthesis (MAOS) affords many beneficial merits. High efficiency or high – throughput in chemical synthesis can be achieved at high reaction temperature under controlled microwave heating along with improved conversion rate, product selectivity, and reproducibility. We initiated a research program in MAOS and have demonstrated the unique temperature – controlling feature of dedicated microwave reactor in high regioselective Wittig olefination,[1a] one – pot heterocycle synthesis[1b] and solid – phase combinatorial synthesis.[2] In this presentation, recent progress in compound library synthesis through MAOS is discussed.

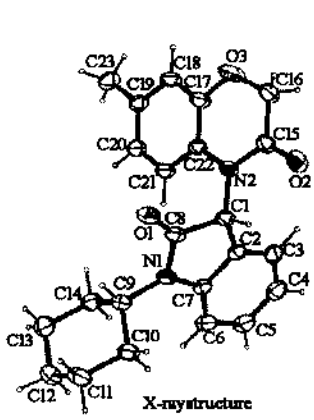
The first topic is the microwave – assisted high – throughput synthesis and screening of library of our amide – derived phosphines (Aphos) for catalysis.[3,4] We present here, for the first time, a chemical process which is initiated by substrate – catalysis and then followed by both substrate – and product – catalysis. We refer it as self – assisted molecular evolution (SAME), being a diversity – generating process for self – generation of a compound library from different building blocks. From Aphos 1 and a collection of $ArB(OH)_2$, we synthesized, in a sequential manner, a library of Aphos 2 and tested them in situ for efficiency in Suzuki reaction of aryl chloride 3. Our efforts have resulted in an efficient Aphos ligand capable of promoting room temperature Suzuki coupling of unactivated and sterically hindered aryl chlorides with arylboronic acids.[5]

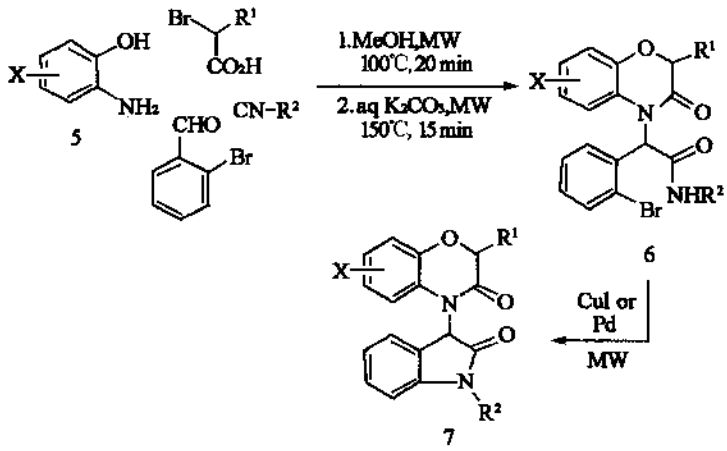


1 2 (validated by ^{31}P NMR) (conversion of 3 analyzed by HPLC or yield of 4 by isolation)

The second topic is the microwave – assisted one – pot multi – component reaction and annulation for rapid access to natural product – like heterocycles. We have established a one – pot pro-

tocol for the microwave – assisted Ugi – 4CR of o – aminophenols 5 followed by O – alkylation to form 1,4 – benzoxazines 6. The latter underwent the Cu – or Pd – catalyzed intramolecular amidation reaction with microwave irradiation to afford 2 – oxindoles 7. By selecting suitable building blocks for the Ugi – 4CR, we have synthesized libraries of heterocycles with different scaffolds.[5]





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Acknowledgement. This work is supported in part by Department of Chemistry, HKUST and Zhejiang University, China.

References

[1] For microwave – assisted organic synthesis, see: (a) Wu, J.; Wu, H.; Wei, S.; Dai, W. – M. Tetrahedron Lett. 2004, 45, 4401 – 4404. (b) Dai, W. – M.; Wang, X.; Ma, C. Tetrahedron 2005, 61, 6879 – 6885.

[2] For microwave – assisted solid – phase organic synthesis, see: Dai, W. – M.; Guo, D. – S.; Sun, L. – P.; Huang, X. – H. Org. Lett. 2003, 5, 2919 – 2922.

[3] For asymmetric catalysis using atropisomeric amide – derived phosphines (A^2phos), see: (a) Dai, W. – M.; Yeung, K. K. Y.; Liu, J. – T.; Zhang, Y.; Williams, I. D. Org. Lett. 2002, 4, 1615 1618. (b) Dai, W. – M.; Yeung, K. K. Y.; Wang, Y. Tetrahedron 2004, 60, 4425 – 4430.

[4] For Suzuki cross – coupling using Aphos, see: (a) Dai, W. – M.; Li, Y.; Zhang, Y.; Lai, K. W.; Wu, J. Tetrahedron Lett. 2004, 45, 1999 – 2001. (b) Dai, W. – M.; Zhang, Y. Tetrahedron Lett. 2005, 46, 1377 – 1381.

[5] Dai, W. – M., et al. unpublished results.

Study on Effect and Significance of Membrane Electro poration on Several Neurons and Cells Induced by EMP and HPM

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Electromagnetic radiation (EMR) can be divided into ionizing radiation (γ - ray, X - ray) and non - ionizing radiation (laser, microwave, radiation frequency), in which high power microwave (HPM) and electromagnetic pulse (EMP) belong to non - ionizing radiation. HPM and EMP occurred not only in peace time (radar, cell phone, TV - pad, et al), but also in war time, e. g. nuclear explosion, HPM weapon, EMP weapon, bomb explosion, et al. The experimental study and epidemiological survey have confirmed that HPM and EMP could induce human injury and health risks, even fatal effects[1-4].

Experimental animal investigation indicated that main target organs included brain - particular hippocampus (nerve - behavior abnormality)[5], endocrine glands, heart - particularly transmission fiber (heart dysfunction, blocking), gonad - test, ovary (dysgenesis, testosterone descent), eye - (lens opacity), lymphatic tissue (immune function descent)[6], hemopoietic tissue (hemopoietic function descent), in which brain was one of the most sensitive.

The injury effects of EMP and HPM were divided into 4 phases: immediate, early phase (within 1 week), middle phase (2 - 4 weeks), late phase (>4 weeks, e. g., lens opacity, encephalatrophy, tumor, dysgenesis, hereditation). After high intensity EMP and HPM irradiation, fatal effects also occurred. The main lethal causes were infection, hemorrhage, and emaciation - dyscrasia. We found the sensitivity of injury and lethal effect have phylogenic difference: monkey was the most, below in proper order were dog, rabbit, rat (mouse).

The mechanisms of injury in HPM and EMP include thermal effect and Non - thermal effect. In the former, temperature of tissue rises about 5 - 11℃, e. g., after mice were irradiated by 2450MHz microwave, the temperature of skin, thoracic cavity and brain rises about 5 - 10℃, 5 - 9 ℃, 6 - 11 ℃, respectively, and result in the degeneration, apoptosis, necrosis of cells; In the latter, the damage region involved mainly cell and molecular structure, including biophysical reaction, biochemical reaction, gene mutation, cellular factor and signal transmission abnormalities, finally result in the injury of tissue, organ, and organism[7].

In order to study the mechanisms of non - thermal effects, this article observed the electroporation effect of EMP and HPM on cultured neurons of hippocampus and hypothalamus, cells of hy-

pophysis and myocardium; investigated the alternation of several ions in cells and culture – liquid; and reveal the significance of electroporation on cell membrane.

Material and methods

Neurons of hippocampus and hypothalamus, cells of hypophysis cells and myocardium of Wistar rat were separately cultured in six 6 – hole boards, one board was control sample. In every cell, the all five boards were irradiated by high field strength 5 EMP within 2 minutes

(electric field intensity 60 KV/m, rise time 20nsec, pulse width 30 μsec), in which myocardial cells were separately irradiated by HPM (power density 950mw/cm^2, pulse width 0.35μsec, irradiated time 60 sec.) and ^{60}Co γ – ray (dose 8 Gy).

The changes of structure on surface of cell membrane of all neurons and cells were observed using Atomic Forces Microscopy (SPM – 9500J3, Japan) after irradiation. The concentration of Ca^{2+}、K^+、Na^+、Mg^{2+}、Cl^-、LDH、AST、CHE in culture medium were measured at 0h, 1h, 6h, 12h, 24h and 48h by reagent boxes (Beijing Zhongsheng high – tech bioengineering Company). The concentration of i[Ca^{2+}] in cells and neurons were measured using Laser Confocal Scanning Microscopy (Radiance2000, Bio – rad). Moreover, the growth activity (MTT) and apoptosis, necrosis (FCM) of various cells and neurons were examined at 0h, 6h, 2h, 24h, 48h after irradiation.

All dates were analyzed by statistical software SPSS 8.0.

Results and discussion

1. In EMP and HPM groups, the electroporation of cell membrane occurred in all cells (neurons of hippocampus and hypothalamus, cells of hypophysis and myocardium). The number, shape, size and depth were different in various cells, in which the number of hole were more, and bigger, wider, deeper in HPM group than that in EMP group. In all irradiated cells the cell membranes were penetrated (the depth was generally 13 – 130nm). In γ – ray group, the electroporation of membranes did not occur. (Fig 1 – 5).

2. The concentration of i[Ca^{2+}] in all irradiated cells and neurons was apparently decreased ($P<0.01$) than that in control group (Fig6).

3. The concentration of Ca^{2+}、Mg^{2+}、Na^+、K^+、Cl^- and LDH、AST、CHE in culture – liquid of various cells and neurons were firstly decreased, then obviously increased ($P<0.01$) than that in control group(Fig7 – 12).

The percentage of apoptosis and necrosis in various irradiated neurons and cells were obviously increased ($P<0.01$) than that in control group (Fig13 – 14, Table1).

The growth activity in all irradiated cells was obviously descent ($P<0.01$ or <0.05), particularly, at 12h (Table 2).

Conclusion

1. EMP and HPM could injure and electroporate the membranes of neurons of hippocampus and hypothalamus, cells of hypophysis and myocardium. Above mentioned electroporation did not occur after γ – ray irradiation.

2. The membrane electroporation induced outflow of multi – ions from cells and occurrence of apoptosis and necrosis of cells.

3. The damage degree of electroporation effect in HPM group was more severe than that in EMP group.

References

[1] Repacholi MH. Low – level exposure to radio frequency electromagnetic fields: health effects and research needs [J]. Bioelectromagnetics, 1998,19(1): 1 – 19.

[2] Fedorowski S, Steciwko A. Biological effects of non – ionizing electromagnetic radiation [J]. Med Pr. 1998.49(1): 93 – 105.

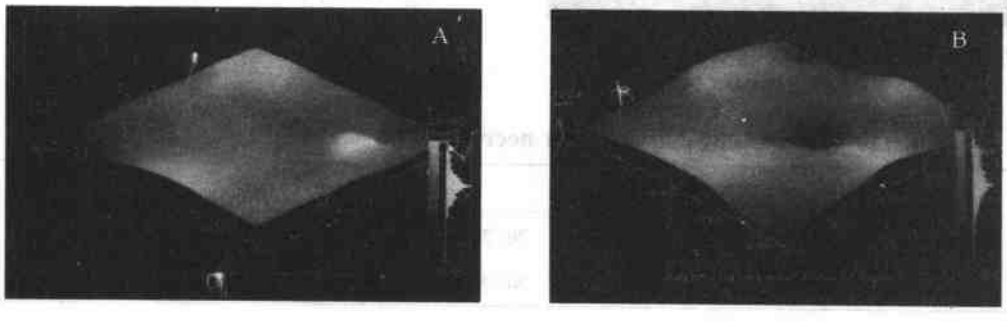
[3] Gailey PC, Easterly CE. Cell membrane potentials induce during exposure to EMP fields [J]. Electro – and Magnetobiology. 1994, 13 (2): 159.

[4] Zhang Hong Feng, Chen Shu De, Wang Yao Fa, et al. The effects of pulsed electric field on dermal fibroblast proliferation and membrane fluidity [J]. Cytobilogy. 1998, (20): 82 – 85.

[5] Zhao Meilan, Ma Qiang, Cao Xiaozhe, et al. Effect of electromagnetic pulse on learning – memory abilities and long – term potentiation in rats [J]. Chin J Phys Med Rehabil. 2001,23 (2): 69 – 71.

[6] Cui Yufang, Yang Hong, Wu Shunxia, et al. Molecular mechanism of damage and repair of mouse thymus lymphocytes induced by radiation [J]. Chinese Medical Journal. 2002, 115 (7): 1070 – 1073.

[7] Cao Xiaozhe, Wang Dewen, Zhao Meilan, et al. Changes on the serum biochemical indexes in rats irradiated by 98.55W/cm^2 pulse microwave [J]. Life Science Research. 2002,6 (1): 79 – 83.



Figl. electroporation of hippocampus neuron A: control. B: irradiated by EMP 60 KV/m

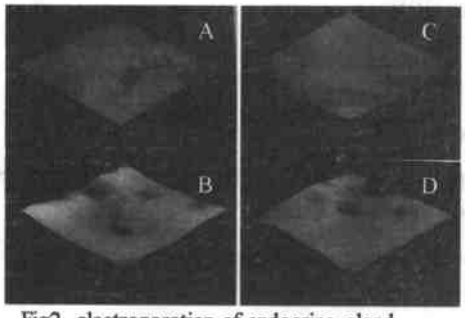


Fig2. electroporation of endocrine gland
Left: hypothalamus; right: hypophysis
A,C: control; B,D: irradiated by EMP

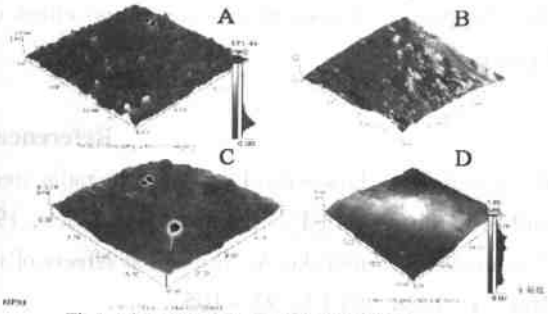


Fig3. electroporation of myocardium
A: control; B: irradiated by EMP;
C: irradiated by HPM; D: irradiated by γ-ray

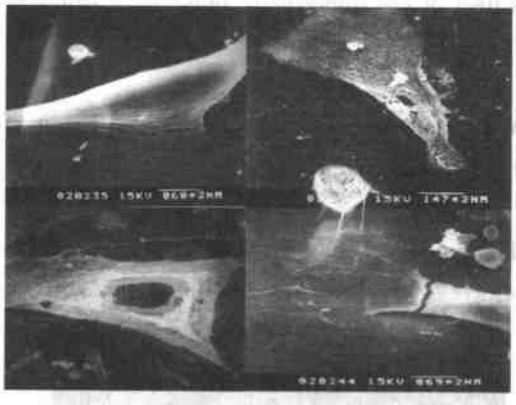


Fig4. electroporatio of myocardium in SEM

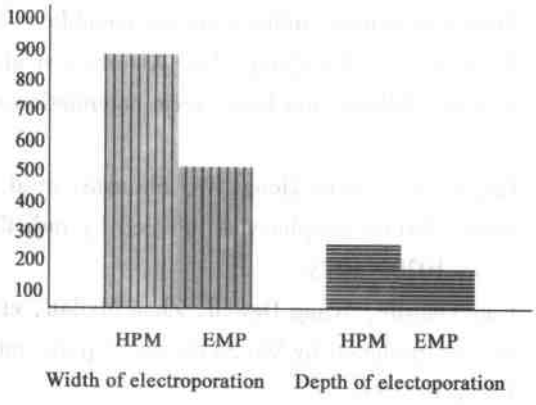


Fig5. comparation of electroporation between HPM and EMP group

Table 1 Rate of apoptosis and necrosis of myocardial cells (HPM)

Death	Control	6h	24h
Apoptosis	2.36 0.87	26.76 5.12**	26.44 2.67**
Necrosis	1.05 0.96	24.78 6.52**	21.35 5.43**

Table 2 The growth activity of myocardial cells after HPM

	0h	6h	12h	24h	48h	72h
EMP	0.40 ± 0.07 *	0.36 ± 0.05 * *	0.18 ± 0.08 * *	0.31 ± 0.07 * *	0.49 ± +0.05	0.54 +0.10
Control	0.59 ± 0.09	0.53 ± 0.12	0.57 ± 0.06	0.62 ± 0.13	0.56 ±0.02	0.58 ± 0.09

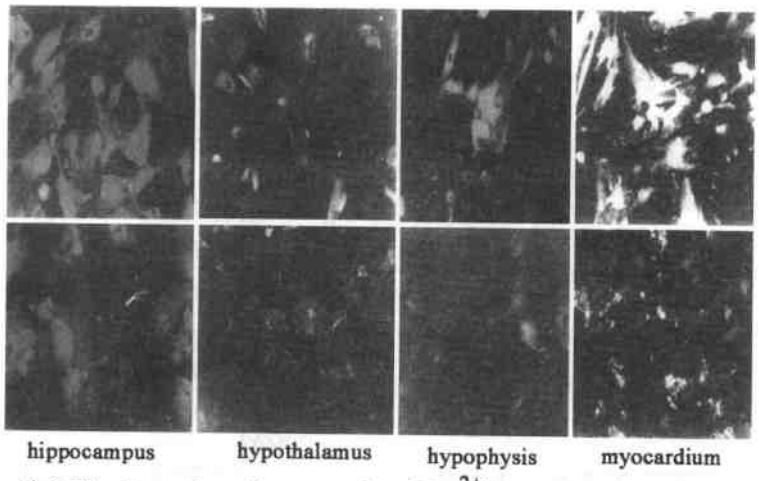


Fig6. The alternations of concentration of i[Ca^{2+}] in several cultured cells after EMP irradiation
Upper.controls; below:irradiated

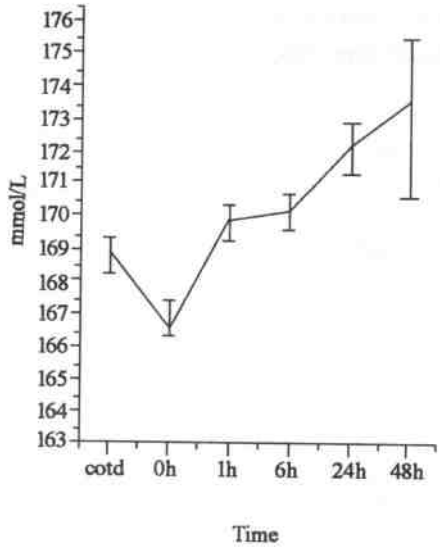


Fig7. concentration of Ca^{2+} in culture-liquid after HPM

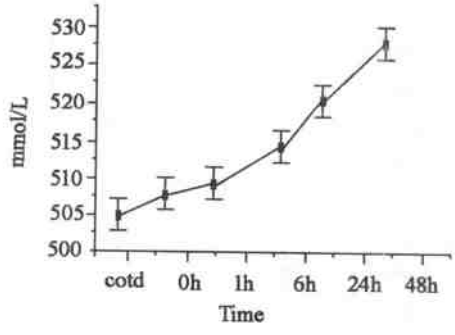


Fig8. concentration of K^{+} in culture-liquid after HPM