Tribute to Dr Constantinos M. Paleos on the occasion of his 80th birthday.

February 2022

On June 6 2021, Dr Constantinos M. Paleos, Former Director of the Institute of Physical Chemistry, at the National Center for Scientific Research "Demokritos", celebrated his 80th birthday. On this occasion, research highlights, covering a wide spectrum of his accomplishments, will be precisely presented. Constantinos was born in the island of Chios, located in the Eastern Agean Sea, where he completed his basic education. He obtained a Diploma in Chemistry from the University of Athens and his PhD from Drexel University in Philadelphia at 1970. After three years with Amoco Chemicals (Naperville, Illinois) and Motor Oil (Athens, Greece), he joined in 1973 the **Institute of Physical Chemistry** of NCSR "Demokritos", where he later established the "**Laboratory of Supramolecular Organized Structures**". In 1991-1992 he was elected visiting Professor at the University of Strasbourg (then University of Louis Pasteur). He was elected Director of this Institute for two periods (1994-1999 and 2001-2007). Currently, he is consultant of the same laboratory at the Institute of Nanoscience and Nanotechnogy of NCSR "Demokritos". Selected highlights of his work on functional molecular and supramolecular systems are critically described below in chronological order.

- **Polymerization of Organized Molecular and Supramolecular Systems**

Following undergraduate studies in Athens University, Paleos was for the first time exposed to chemical research and specifically to synthetic organic chemistry during the period of his military service, working as a research assistant in the laboratory of Prof. **L. Zervas** at the Organic Synthesis Lab of the University of Athens. Zervas was a pioneer in the field of **Peptide Synthesis** and specifically on the design and synthesis of protective groups. He had an exceptional ability, or specifically a "feeling", on designing and preparing organic compounds. The lesson Paleos had learned during his short staying at his lab was to make him proceed to synthetic experiments, after considering basic steps.

In the period of April to August 1966, he worked at the Biology Department of "**Demokritos**", as a research assistant in the laboratory of Dr **A. Bakirtzi-Lemonias**, on co-enzyme Q10 characterization. During his staying at this laboratory, he had the opportunity of being exposed in basic biochemical techniques.

The work towards his PhD degree started in 1967, at Drexel University in Philadelphia, USA and he was supervised by Prof. **M. M. Labes** who is a pioneer in the field of liquid crystals and from whom he was taught to seek innovation and try finding innovative solutions to various problems. Paleos was introduced to the exciting field of liquid crystals and investigated the role of organization on chemical reactivity and properties of the materials obtained.

An appropriate system for conducting these investigations is to perform polymerization reactions in organized **Thermotropic Liquid Crystalline Phases** formed by rigid-rod molecules [1]. The emphasis was placed on polymerizations in liquid crystalline media and the effects of organization

on reactivity and polymer morphology. The publications of this novel, at that time, work were among the first to appear in the chemical literature.

In those early years and while he was still working on the topic of his PhD thesis, 1967-1970, he started investigating, in parallel, chemical reactions of **Nitroxide Stable Free Radicals**. These compounds due to their stability are being used in spin-labelling technique. The outcome of this independent work was published in prestigious journals but most importantly, these first publications [2,3] in the field of Nitroxide Free Radicals, convinced him, at this early period, about his ability to conduct independent research.

- **Liquid Crystals Originating from Amphiphilic Molecules**

In the early seventies, upon his return in Greece, while working at **Demokritos** and having been inspired by his previous work on polymerizations in organized thermotropic liquid crystalline media, Paleos extended his research to other more conveniently prepared organized systems. He investigated polymerization reactions at liquid-liquid interfaces and polymerizations of monomers assembled in micelles [4] or assembled and organized in vesicles [5]. In conducting this work he was inspired by the investigations of Prof. **H. Ringsdorf**, as presented in his excellent review (H. Ringsdorf et al., J. Angew. Chem., Int. Ed. Engl. 1988, 27, 113-158). At that time, when these investigations were conducted, these molecular assemblies were characterized as colloidal. Now, based on their size they are also called nanoparticles. Therefore, colloid chemistry is bridged to the spectacularly advancing field of nanoscience-nanotechnology.

In the early eighties, Constantinos started investigating thermotropic liquid crystalline phases originating from **Amphiphilic Molecules**, which was a neglected area up to that time. In fact his first short note in Mol. Cryst. Liq. Cryst. [6] triggered great interest for the preparation and characterization of this type of thermotropic liquid crystals. Detailed characterization of these liquid crystalline materials was initiated in Strasbourg (1991-92) during his visiting professorship at the University of Strasbourg and continued the following years through a fruitful collaboration with Dr **A. Skoulios** at CNRS. Dr Skoulios is a great expert in the field of liquid crystalline characterization with X-ray crystallography. Numerous publications resulted from this joint effort, both of original research and reviews, triggering interest in the synthesis of amphiphilic molecules which self-assemble and organize forming thermotropic liquid crystals in the bulk and lyotropic liquid crystals when in water.

- **Hydrogen-bonded Liquid Crystals Obtained through Molecular Recognition**

Following the first publication on "**Hydrogen-bonded Liquid Crystals**" by the Nobel Laureate **J. M. Lehn** in 1989 [J. Chem. Soc., Chem. Commun., 1989, 1868-1870], Paleos was among the first researchers around the world to start investigating the preparation and characterization of this type of liquid crystals resulting from the **molecular recognition** of complementary molecules through hydrogen bonding. A great number of original publications resulted, the majority of which was discussed in his highly cited reviews, in Angew. Chem., 1995 [7] and Liquid Crystals, 2001 [8].

In connection with this work, Molecular Recognition of Organized Molecular Assemblies, via hydrogen bonding in aqueous media, was also investigated [9].

- **Development of Functional and Multifunctional Dendritic Polymers**

In the mid-nineties, Paleos entered the highly advancing field of **Functional Dendritic Polymers** in which he is intensively involved up to recent years [10-14]. Dendritic polymers, primarily due to their **polyvalent properties**, provide a diversity of products such as:

- **Liquid crystalline polymers** based on symmetric dendrimers and non-symmetric hyperbranched polymers were prepared, which provided a diversity of liquid crystalline phases. The relevant publications were extensively cited.
- **Alkylated dendritic polymers**, either covalently or non-covalently bound to ceramics, forming **Hybrid Materials.** These materials act as "**nanosponges**" removing impurities from water under energy-saving conditions. Ultra-pure water is produced in which the remaining impurities are at the level of a few ppb, following filtration of water through hybrid material filtering modules. The latter are regenerated by washing with appropriate solvents. Patent applications in several countries were filed and granted, while several pertinent publications followed.
- **Multifunctional dendritic derivatives** had been intensively investigated as **Drug Delivery Systems** or transfection vectors for **Gene Therapy** *in vitro* experiments. Patent applications in several countries were filed and patents granted, while the results were disseminated in several publications. In this connection a dendritic-type semisynthetic carbohydrate, i.e. Hydroxyethyl starch (HES), was functionalized affording biodegradable drug carriers. Doxorubicin, an anticancer drug, was non-covalently attached to this carrier and the salt was subjected to in vitro experiments which proved very promising. These first results triggered increased interest on the synthesis and characterization of drugs based on this novel and biodegradable dendritic drug delivery system [15].

The last two activities led to establishing a spin-off Company, "DendriGen SA," for commercial exploitation of the developed nanoparticles.

- **Functional and Multifunctional Liposomes - Biological Cell Modelling - Drug Delivery Systems**

The expertise in the development of synthetic vesicles already from the eighties, led Paleos to start working in 2000 towards the development of **Multifunctional Liposomes** aiming at their application as drug delivery systems or as biological cell models [15-19]. Also a comparative evaluation of multifunctional liposomes vs. multifunctional dendritic derivatives as drug delivery systems was undertaken.

Within the objective of developing drug delivery systems, Paleos extended his work from molecular recognition of complementary molecules to the recognition of self-assembled nanoparticles. Thus, he investigated liposome-liposome and liposome-dendritic polymer

interactions. A mechanism for the interaction of these nanoparticles has been proposed aiming at modelling cell-cell and cell-drug interactions in drug delivery. These investigations were published and reviewed in several prestigious journals [15-19].

A significant outcome of the work dealing with liposome-liposome interactions led to proposing a working hypothesis regarding the origin of eukaryotes (Journal of Molecular Recognition 2007, Langmuir 2011, and Accounts of Chemical Research 2014). Thus, based on the results of complementary liposome interactions, it was hypothesized [20,21] that eukaryotes, which exhibit a multicompartment character, might have originated from the symbiotic association of prokaryotes.

- **Molecular Transporters: Guanidinium or Triphenylphosphonium decorated Liposomes and Dendritic Polymers**

Within the framework of his investigations on drug delivery, Paleos has undertaken research on decorating the surface of liposomes or dendritic polymers aiming to the development of molecular transporters [22]. The guanidinium moiety facilitates cell membrane transport, while the triphenylphosphonium cation directs the latter nanoparticles to mitochondria. These phosphonium derivatives are characterized as second generation transporters. For the guanidinium functionalized transporters, he proposed a novel multi-step mechanism for membrane penetration [23,24]. Several original publications and reviews in prestigious journals have resulted from this continuing effort.

In the last years, due to his interest on the origin of living cells, Paleos has experienced a great satisfaction realizing that his early research involvement, on organized polymerization in liquid crystalline media, and on the structure and properties of amphiphilic-type liquid crystals, is related in some way to the issue of the Origin of Life [D. W. Deamer, Chem. Soc. Rev. 41, 5375-5379 (2012)]. According to this investigation, polymerization of mononucleotides to RNA-type polymers took place, in the absence of catalyst, in liquid crystalline media during the prebiotic era.

During the long career of Paleos at "Demokritos", in which he started as a project chemist, he was elected and served for two periods (1994-1999 and 2001-2007) as **Director of the Institute of Physical Chemistry.** During this period he restructured the Institute, by changing its priorities and establishing new areas of research. Specifically, he established the Programs of ***"Environmental Science and Technology"***, ***"Chemical Biology"*** and ***"Molecular and Supramolecular Nanomaterials"***.

Further to focusing to **Nanochemistry and Supramolecular Chemistry** as described above and included in selected references [1-24], Paleos also worked in topics of conventional chemistry including synthetic and mechanistic organic chemistry, polymer modification, nitroxide stable free radicals chemistry. Details of this research are included in respective publications.

Excellence coupled with diversification of his research activity is reflected in a great number of publications and patents. He has authored together with his co-workers 181 publications which were cited more than 6500 times in the period from 1970 to February 2022.

Selected Publications

1. C. M. Paleos and M. M. Labes*, Polymerization of a Nematic Liquid Crystal Monomer, Mol. Cryst. Liq. Cryst., **11**, 385 (1970).

2. C. M. Paleos*, N. M. Karayiannis and M. M. Labes, Reduction of 2,2,2,6 Tetramethyl-piperidine Nitroxide Radical via Complex Formation with Copper (II) Perchlorate, Chem. Comm., 195 (1970).

3. C. M. Paleos* and P. Dais, A Ready Reduction of Some Nitroxide Free Radicals with Ascorbic Acid, Chem. Comm., 345 (1977).

4. C. M. Paleos, Polymerization of Micelle Forming Monomers, in "Polymerization in Organized Media" Editor: C. M. Paleos, Gordon and Breach Publishers, New York, Philadelphia, p. 183, 1992.

5. C. M. Paleos, Polymerization in Vesicular Media, in "Polymerization in Organized Media", Editor: C. M. Paleos, Gordon and Breach Publishers, New York, Philadelphia, p. 283, 1992.

6. C. M. Paleos, Thermotropic Liquid Crystals Derived from Amphiphilic Mesogens, Mol. Cryst. Liq. Cryst., **243**, 159 (1994).

7. C. M. Paleos*, D. Tsiourvas, Thermotropic Liquid Crystals Formed by Intermolecular Hydrogen Bonding Interaction, Angew. Chem. Intern. Engl. Ed., **34**, 1696 (1995).

8. C. M. Paleos* and D. Tsiourvas, Supramolecular Hydrogen-bonded Liquid Crystals, Liq. Cryst., **28**, 1127 (2001).

9. C. M. Paleos* and D. Tsiourvas, Molecular Recognition of Organized Assemblies via Hydrogen Bonding in Aqueous Media, Advanced Materials, **9**, 695 (1997).

10. C. M. Paleos*, D. Tsiourvas and Zili Sideratou, Molecular Engineering of Dendritic Polymers and their application as Drug and Gene Delivery Systems, Molecular Pharmaceutics, **4**, 169 (2007).

11. C. M. Paleos*, L-A Tziveleka, Z. Sideratou and D. Tsiourvas, Gene Delivery Using Functional Dendritic Polymers, Expert Opinion on Drug Delivery, **6**, 27-38 (2009).

12. M. Arkas, D. Tsiourvas and C. M. Paleos*, Functional Dendritic Polymers for the Development of Hybrid Materials for Water Purification, Macrom. Mater. Eng., **295,** 883 (2010).

13. C. M. Paleos*, D. Tsiourvas, Z. Sideratou and L.-A. Tziveleka, Drug Delivery Employing Multifunctional Dendrimers and Hyperbranched Polymers, Expert Opinion on Drug Delivery, **7**, 1387 (2010).

14. C. M. Paleos*, D. Tsiourvas and Z. Sideratou, Triphenylphosphonium Decorated Liposomes and Dendritic Polymers: Prospective Second Generation Drug Delivery Systems for Targeting Mitochondria, Molecular Pharmaceutics, **13**, 2233 (2016).

15. C. M. Paleos*, Z. Sideratou and D. Tsiourvas, Drug Delivery Systems based on Hydroxyethyl Starch, Bioconjugate Chemistry, **28**, 1611 (2017).

16. C. M. Paleos*, Z. Sideratou and D. Tsiourvas, Molecular Recognition of Complementary Liposomes is Modelling Cell-Cell Recognition, ChemBioChem., **2**, 305 (2001).

17. C. M. Paleos*, D. Tsiourvas and Z. Sideratou, Interaction of Vesicles: Adhesion, Fusion and Multicompartment Systems Formation, ChemBioChem, **11**, 510 (2011).

18. C. M. Paleos*, D. Tsiourvas and Z. Sideratou, Multicompartment Lipid-based Systems prepared from Vesicles Interactions, Langmuir, **28**, 2337 (2012).

19. C. M. Paleos*, D. Tsiourvas, Z. Sideratou and A. Pantos, Formation of Artificial Multicompartment Vesosome and Dendrosome as Prospected Drug and Gene Delivery Carriers, J. Controlled Release, **170**, 141 (2013).

20. C. M. Paleos* and A. Pantos, Molecular Recognition and Organizational and Polyvalent Effects in Vesicles Induce the Formation of Artificial Multicompartment Cells as Model Systems of Eukaryotes, Acc. Chem. Res., **47**, 475, (2014).

21. C. M. Paleos*, Organization and compartmentalization by lipid membranes promote reactions related to the origin of cellular life, Astrobiology, **19**, 547 (2018).

22. C, M. Paleos*, D. Tsiourvas and Z. Sideratou, Triphenylphosphonium Decorated Liposomes and Dendritic Polymers: Prospective Second Generation Drug Delivery Systems for Targeting Mitochondria, Molecular Pharmaceutics, **13**, 2233 (2016).

23. Pantos, I. Tsogas and C. M. Paleos*, Guanidinium Group: A Versatile Moiety inducing Transport and Multicompartmentalization in Complementary Membranes, BBA-Biomembranes, **1778**, 811 (2008).

24. T. A. Theodossiou, A. Pantos, I. Tsogas and C. M. Paleos*, Guanidinylated Dendritic Molecular Transporters: Prospective Drug Delivery Systems and Application in Cell Transfection, ChemMedChem, **3**, 1635-1643 (2008).

Curriculum Vitae

Dr Constantinos M. Paleos

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Education

Diploma in Chemistry, University of Athens, Greece, (1964).

PhD in Chemistry, Drexel University, Philadelphia, Pa, USA, (1970).

Appointments

Mar. 1966 - Aug.1966: N.R.C. "Demokritos", Research Assistant. Sept.1966.

Feb 1970: Graduate Studies at Pennsylvania State and Drexel Universities, USA, Research and Teaching Assistant

Feb.1970-Dec. 1970: Standard Oil Co., IND, Amoco Chemicals, Project Chemist.

Feb. 1971 - Oct. 1973: Motor Oil (Hellas), Project Chemist, Consultant.

Jan. 1973 – July 2007: NCSR "Demokritos", Research Director.

Oct. 1991 - Mar.1992: Visiting Professor at the University Louis Pasteur, Strasbourg, France.

Nov. 1994 - Nov 1999: Director, Institute of Physical Chemistry, NCSR "Demokritos".

Dec. 1994 - Dec.1996: Vice-President of the Board, NCSR "Demokritos"

June 2001- July 2007: Director, Institute of Physical Chemistry

Oct. 2007- Today: Consultant and Collaboration with my previous team at the Institute of Nanoscience and Nanotechnology at "Demokritos."

Field of Research - Research Interests.

- Supramolecular liquid crystals - Biomimetic liquid crystals - Liquid crystals based on functional dendrimers.
- Molecular recognition between complementary liposomes and also between liposomes and simple monomeric or polymeric moleculeds.
- Preparation and characterization of liposomes and application as drug delivery systems.
- Functionalization of dendrimers and hyperbranched polymers for prospected applications as drug delivery systems and gene transfection vectors.
- Preparation of dendritic molecular transporters and mechanism of action.
- Application of functional and cross-linked dendrimers and hyperbranched polymers as "Nanosponge" materials for water purification.
- Adhesion, Fusion and Multicompartment Systems formation in interacting vesicles - Modelling cell processes.

Fellowships

1960 - 1964: State Fellowship for Undergraduate Studies at Athens University.

1967 - 1969: NASA Fellowship at Drexel University.

1969 - 1970: Fellowship from the Department of the Army, Edgewood Arsenal Research Laboratories, Maryland, at Drexel University.

Publications-Patents-Presentations

My work is covering an **exceptional broad spectrum of Science and Technology** and has been included among others (patents and presentations) in 181 original articles and reviews of prestigious Journals of high Impact Factor such as:

Accounts of Chemical Research, Angewandte Chemie, Trends in Biochemical Science, Journal of Physical Chemistry, Journal of Organic Chemistry, Chemical Society Reviews, Chemical Communications, Chemistry, A European Journal, Astrobiology, Advanced Materials, Macromolecules, Biomacromolecules, International Journal of Pharmaceutics, Makromolekulare Chemie, Molecular Pharmaceutics, Liquid Crystals, Molecular Crystals and Liquid Crystals, Journal of Colloid and Interface Science, Journal of Macromolecular Science, Reviews in Macromolecular Chemistry and Physics, Chemistry and Physics of Lipids, Journal of Polymer

Science, Polymer Chemistry Edition, Journal of Applied Polymer Science, Polymer and Progress in Colloid and Polymer Science.

Citations: Over 6.100 citations as of August of 2020 (Source Google Scholar). ***h-index*** **41**.

My work has been cited many times by Nobel Laureate Prof. **J.M**. **Lehn** and by several other researchers, the majority of which referred with very positive comments to my publications, such as: **D**. **Reinhoudt**, **J. M. J. Frechet**, **H. Ringsdorf**, **G. Gray, F. M. Menger D. Deamer**, **S**. **Regen**, **G. M**. **Whitesides**, **J**. **H**. **Fendler**, **N**. **Plate**, **D**. **A**. **Tomalia**, **T**. **Kunitake**, **V**. **V**. **Egorov**, **C**. **E**. **Hoyle**, **K**. **Nagai**, **T**. **Kato**, **A**. **Laschewsky**, **G**. **R**. **Newkome**, **A. D'Emanuele**, **R. J. Mart**, **P. R. Dvornic**, **H. Jin, Y. Zhou**, **B. Donnio**, **V. Torchilin, R. Haag, S. J. Webb, J.F. W. Keana, N. K. Jain, P. Baglioni, H. Rosemeyer, S. C. Zimmerman, H. Mohwald, R. Angius, S. Diele, M. I-Clerc, C. A. Mirkin, M. Summers, J.R. Baker Jr, C. Tschierske, M. Seiler, K. Binnemans, A. Sosnik, C. Kojima, K. Petrak**, **R. Haag** etc.

Professional Activities - Other

1. Member of the Greek Chemical Society.
2. Member of the American Chemical Society.
3. Member of the Editorial Board of "Molecular Crystals and Liquid Crystals".
4. Member of the Editorial Board of Journal of Soft Matter.
5. Member of the Editorial Board of JSM Chemistry, JSciMed Central.
6. Member of the Principal Editors of "NanoLife".
7. Member of the Liquid Crystalline Society.
8. Member of COST Management Committee, D11 Supramolecular Chemistry and D27 Prebiotic Chemistry and Origin of Life.
9. Editor of the book «Polymerization in Organized Media», Gordon and Breach Science Publishers, Philadelphia - Paris - Tokyo (1992).

Reviewer of many European and American Journals as shown below:

Due to the diversity of my research activity, I have act as reviewer for many prestigious journals as follows: Nature, Journal American Chemical Society, Angewandte Chemie, Chemical Reviews, Chemical Commnications, Langmuir, Journal of Physical Chemistry, Chemistry, A

European Journal, Liquid Crystals, Macromolecules, Biomacromolecules, Macromolecular Bioscience, Journal of Colloid and Interface Chemistry, Life, Molecular Crystals and Liquid Crystals, Journal of Polymer Science, Polymer Chemistry Edition, Journal of Organic Chemistry, Supramolecular Chemistry, Colloids and Surfaces, Carbohydrate Research, BBA, Biomembranes, etc.

Educational Activities

Participation in the Graduate Programme of Demokritos". Eleven PhD and five MSc degrees were awarded by work performed in our laboratory. Teaching at graduate level at the University of Athens.

Brief Analysis of Scientific Work

The work towards my PhD degree was supervised by Prof. M. M. Labes, a pioneer in the field of liquid crystals, who introduced me to this field and specifically, into the topic of "Reactions in Thermotropic Liquid Crystalline Phases". The emphasis was placed on the polymerization in liquid crystalline phases and the effects of organization on reactivity and polymer morphology. The publications that originated from this pioneering work were among the first to appear in the literature and they were extensively cited.

In the 1970s, inspired by the polymerization in organized thermotropic liquid crystalline media, I extended my work to other organized media, investigating polymerizations and oxidations at liquid-liquid interfaces and polymerizations of monomers organized in micelles or liposomes. These molecular aggregates, i.e. the micelles and the liposomes, are organized supramolecular systems, resulting from the self-assembly of amphiphilic molecules. At that time they were characterized as colloidal systems, while now they are considered as nanoparticles due to their size. Therefore, colloid chemistry is bridged to the spectacularly advancing field of nanoscience. A great number of highly cited publications and critical reviews resulted from this work. Moreover, I was the editor of the book "Polymerization in Organized Media", Gordon and Breach Science Publishers, in which I also contributed with two of its seven chapters.

Early in the '80s, I introduced an innovative methodology for the preparation of liquid crystalline polymers by interacting reactive polymers with mesogenic molecules. The method proved to be convenient affording liquid crystalline polymers whose molecular weight and structure is affected by the original polymers. The relevant publications were extensively cited.

In 1982, I investigated thermotropic liquid crystals phases originating from amphiphilic molecules, which was an area neglected until that time. My first short note in Mol. Cryst. Liq. Cryst. kindled international interest for the preparation and characterization of this type of thermotropic liquid crystals. The detailed characterization of these liquid crystalline materials was initiated in Strasbourg (1991-92) during my visiting professorship in the University of Louis Pasteur and continued the following years through a fruitful collaboration with Dr A. Skoulios of CNRS. Numerous publications resulted from this joint effort, both of original research and review type, triggering the interest for the synthesis of amphiphilic molecules, which self-assemble and organize forming thermotropic liquid crystals and lyotropic liquid crystals when dissolved in water.

Following the first publication on "Hydrogen-bonded Liquid Crystals" [(J. M. Lehn, ChemComm 1989), Nobel Laureate], I was one of the first researchers around the world to start investigating the preparation and characterization of this type of supramolecular liquid crystals resulting from the assembly of complementary molecules through hydrogen bonding. My seminal review article in Angew. Chem., 1995, is extensively cited while my recent review in Liquid Crystals, 2001 is also highly cited.

In the mid-1990s, I entered the field of dendritic nano-sized polymers and I am intensively continuing research on these polymers until today. Three types of nanomaterials are being prepared and characterized:

a. Liquid crystalline polymers based on symmetric dendrimers and non- symmetric hyperbranched polymers, providing a diversity of liquid crystalline phases. Relevant publications are extensively being cited.

b. Functional dendritic polymers form hybrid materials by intergrading these polymers with ceramics through covalent or non-covalent bonding. These materials act as "nanosponges" removing impurities from water under energy-saving conditions. Ultra-pure water is produced with its remaining impurities to the level of a few ppb, following filtration through these filtering modules. The latter are regenerated by washing with appropriate solvents. Patent applications in several countries were filed and patents granted while several publications followed.

c. Multifunctional dendritic derivatives are currently investigated by our group as drug delivery systems or transfection vectors for gene therapy in in vitro experiments. Patent applications in several countries were filed and patents granted while the results were disseminated by several publications. Experiments in vivo are planned in the near future.

My last two activities culminated in the establishment of a spin-off Company, “DendriGen SA,” for commercial exploitation of the developed nanoparticles.

Starting from 2000, I am involved in the development of multifunctional liposomes aiming at their application as drug delivery systems. Comparative evaluation of liposomes to dendritic multifunctional derivatives, as drug delivery systems, is being undertaken.

I have recently extended my activity from molecular recognition of complementary molecules to the recognition of self-assembled nanoparticles. Thus, I have investigated liposome-liposome and liposome-dendritic polymer interactions. I have studied in detail the mechanism of interaction of these nanoparticles aiming at modelling cell-cell and cell-drug interactions in drug delivery. These investigations were published and reviewed in several prestigious journals.

A significant outcome of the work dealing with liposome-liposome interaction led to proposing a working hypothesis regarding the origin of eukaryotes (Journal of Molecular Recognition 2007, Langmuir 2011, Accounts of Chem. Res 2014). Thus, based on the results of complementary liposome interactions, it was hypothesized that eukaryotes which exhibit multicompartment character, may have originated from the symbiotic association of prokaryotes.

Transport through cell membrane is also a current major activity of our Laboratory. Dendritic polymers have been multi-functionalized in order to exhibit typical characteristics of peptide molecular transporters, which effectively cross cell membranes. I proposed a transport mechanism and several publications in prestigious journals have resulted from this continuing effort.

During my long career at the Institute of Physical Chemistry, I was also involved in topics of conventional chemistry including synthetic and mechanistic organic chemistry, polymer modification, nitroxide spin-labeling chemistry etc before focusing to Nanochemistry and Supramolecular Chemistry.

I served for two periods (1994-1999 and 2001-2007) Director of the Institute of Physical Chemistry, of NCSR “Demokritos”, which I reorganized, changing its priorities and establishing new areas of research. Specifically I established the Programs of Environmental Science and Technology, Chemical Biology and Molecular and Supramolecular Nanomaterials.

The excellence coupled with productivity of my research activity is reflected in a great number of publications and patents. I authored 181 publications 163 of which are included in the Web of Science, which were cited more than 6.100 times in the period from 1970 to August 2020 {Google Scholar}. Also, I supervised the completion of 13 PhD and 7 MSc Theses.

PUBLICATIONS

1. C. M. Paleos, Reactions in the Liquid Crystalline Phase, Dissert. Abts. Internat. B, 31, 2574, 1970 - 71 (PhD Thesis, Supervisor, Prof. M.M. Labes, USA).

2. C. M. Paleos, T. M. Laronge and M. M. Labes*, Liquid Crystal Monomers: N - (p - Alkoxybenzylidene)-p-aminostyrenes, Chem. Comm., 1115 (1968).

3. N. M. Karayannis,* C. M. Paleos, L. L. Pytlewski, and M. M. Labes, Binuclear chlorine - Bridged Complexes of Manganese (II) and Nickel (II) chlorides with Pyridine N- oxides, Inorg. Chem., **8**, 2559 (1969).

4. C. M. Paleos*, N. M. Karayiannis and M. M. Labes, Reduction of 2,2,2,6 Tetramethyl - piperidine Nitroxide Radical via Complex Formation with Copper (II Perchlorate, Chem. Comm. 195 (1970).

5. I. Teucher, C. M. Paleos and M. M. Labes*, Properties of Structurally Stabilised Anil - Type Nematic Liquid Crystals, Mol. Cryst. Liq. Cryst., **11**, 187 (1970).

6. C. M. Paleos and M. M. Labes*, Polymerization of a Nematic Liquid Crystal Monomer, Mol. Cryst. Liq. Cryst. **11**, 385 (1970).

7. Κ. Μ. Παλαιός, Υγροί Κρύσταλλοι – Μερικαί Εφαρμογαί εις την Χημεία, Θέματα Συγχρόνου Τεχνολογίας, Τεύχη **5** και **6**, 33, 33 (1972).

8. N. M. Karayiannis*, C. M. Paleos, C. M. Mikulski, L. L. Pytlewski, H. Blum and M. M. Labes, Some Divalent 3d Metal Perchlorate Complexes with 2,2,6,6-Tetramethylpiperidine Nitroxide Free Radical, Inorg. Chim. Acta, **7**, 74 (1973).

9. Κ. Μ. Παλαιός, Σταθεραί Ελεύθεραι Ρίζαι του Νιτροζειδίου – Ιχνηθέται Σπιν Βιολογικών Συστημάτων, Θέματα Συγχρόνου Τεχνολογίας, Τεύχος **11**, 52 (1973).

10. Κ. Μ. Παλαιός, Πετροχημική Βιομηχανία - Πετροχημικά, Θέματα Συγχρόνου Τεχνολογίας , Τεύχος **12**, 30 (1973).

11. C. M. Paleos*, F. S. Varveri and G.A. Gregoriou, Some New Arenesulfonate Leaving Groups Less Reactive than the p -Toluenesulfonate Group, J. Org. Chem., **39**, 3594 (1974).

12. G. A. Gregoriou* and C. M. Paleos, Nucleophillic Assistance in Solvolysis: II. A useful Solvet System for Estimating the Magnitude of Solvent Assistance, Chimica Chronika, New Series, **3**, 103 (1974).

13. Κ. Μ. Παλαιός, Βιο-μιμητική Χημεία, Χημικά Χρονικά, Γενική Εκδοση ,Τεύχος **2**, 25 (1977).

14. C. M. Paleos* and P. Dais, A Ready Reduction of Some Nitroxide Free Radicals with Ascorbic Acid., Chem. Comm., 345 (1977).

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