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Luminescence of Europium complex enhanced by surface plasmons of gold nanoparticles for possible application in luminescent solar concentrators☆

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ABSTRACT

The paper consists of two parts, the first part is a short description of continuous brilliant scientific activity of Renata Reisfeld and the second part consists of the new findings of luminescence of Europium complex increased by surface plasmons of gold nanoparticles. The studies were performed in Jerusalem for improvement of efficiency of luminescent solar concentrators. The paper describes synthesis of gold nanoparticles and their incorporation into organically modified silica sol-gel matrix co-doped by Europium complex with ligands of EDTA and polyvinylpyrrolidone. The steady state spectroscopy of samples undoped and co-doped by nanoparticles reveals increase of fluorescence of the complexes in presence of gold nanoparticles. The phenomenon arises from scattered light by the nanoparticles and possibly energy transfer.

Renata Reisfeld is an Israeli Professor of Chemistry and D.H.C. Enrique Berman Professor of Solar Energy at Institute of Chemistry of the Hebrew University of Jerusalem, Israel.

Renata Reisfeld's research is centered on theoretical and practical study of sophisticated glasses including luminescent solar concentrators for less expensive photovoltaic electricity, solid state visible lasers, waveguide visible lasers, nonlinear optics, electrochromic glasses, photochromic glasses. She is also engaged in spectroscopy and energy transfer of rare earths and transition metal elements; nanotechnology of quantum dots and noble metal plasmon in glasses.

Renata Reisfeld is a brilliant scientist and a very dear teacher of mine is blessed with extraordinary scientific and social achievements. In Fig. 1 is shown Renata Reisfeld in her laboratory.

In 1993 she received her first an Honorary degree – Doctor Honoris Causa from the University of Lyon, France, video: https://www.youtube.com/watch?v=j6ECAV9jqK8.

In 1993 she was awarded the Medal for scientific achievement of Mayor Lyon, France. Video from the Mayor Lyon: https://www.youtube.com/watch?v=kcML-GwVGcc.

In 1998 she received the Honorary degree – Doctor Honoris Causa from the University of Bucharest, Romania.

In 2005 she received the Honorary degree – Professor Honoris Causa from the Polish Academy of Science, Wrocław, Poland. Video at the Polish Academy of Science, Wrocław, Poland: https://www.youtube.com/watch?v=9lLWoxK-_3E.

In 2005 Polish Ambassador in Israel initiated Ceremony at The Hebrew University of Jerusalem for three Israeli scientists including Professor Reisfeld (Part 1): https://www.youtube.com/watch?v=8UyLt8vpPic.

(Part 2): https://www.youtube.com/watch?v=V16c9uDfshA.

In 2010 she was awarded the Gold Medal of the University of Wrocław, Poland.

Some examples are: Doctor Honoris Causa from University Claude Bernard Lyon I, France; Doctor Honoris Causa from the University of Bucharest, Romania; Professor Honoris Causa from the Polish Academy of Science, Wroclaw, Poland; Medal for scientific achievement of Mayor Lyon, France; Gold Medal of the University of Wroclaw, Poland; Prize of the Israeli Chemical Society.

List of scientific activities of Renata Reisfeld includes 540 papers (cited more than 40,000 times), 3 books, 6 international patents; 230 plenary and invited lectures at international scientific conferences; organizing (and co-organizing) and proceedings editing of 10 international scientific conferences and editorial board membership: Chem. Phys. Lett., Material Science, Ceramic International and Chemical Sensors.

Reisfeld became the head of the science research team at The Institute of Chemistry of the Hebrew University of Jerusalem in 1975. Reisfeld's research interests are luminescent solar concentrators for decreasing the price of photovoltaic electricity, interaction of nanoparticles with luminescent species, anti-reflecting coating, and sol-gel

☆ Dedicated to Renata Reisfeld for her pioneering work in photovoltaics, outstanding contribution to luminescence and continuous international cooperation.

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Fig. 1. Professor Renata Reisfeld is working in her laboratory.

glasses. She began developing solar concentrators with her research team in 1978.

Reisfeld co-organized (with Professor Georges Boulon of Lyon, France) 7 Israeli-French science conferences on Solid State Lasers and related subjects. Reisfeld also co-organized Israeli-Polish Science Conferences with Professor W. Strek, Professor J. Legendziewicz, Professor A. Suchocki, Professor M. Pietraszkiewicz, and Professor E. Rysiakiewicz-Pasek.

International science research cooperation by Reisfeld includes Professor A. Vaseashta (United States), Professor G. Boulon (France), Professor G. Baldacchini(Italy), Professor M. Casalboni(Italy), Professor C. Klingshorn (Germany), Professor D. Enke (Germany), Professor W. Strek, Professor J. Legendziewicz, Professor M. Pietraszkiewicz, Professor B. Jasinska, Professor A. Grabowska, Professor E. Rysiakiewicz-Pasek, Professor M. Grinberg, Professor J. Misiewicz, Dr. K. Wodnicka (Poland), Professor J. Daniel (Spain), Professor I. N. Mihailescu (Romania), Professor O. Malta (Brazil), Professor A. Patra (India), Professor J.-C. G. Bunzli (Switzerland), Professor Jurijs Dehtjars (Latvia), Professor B. Orel (Slovenia), Professor J. Langer (Poland).

Following invitation of Renata Reisfeld by Georges Boulon and Madame Gaume to the International conference on Luminescence in Lyon held in July 1976. What happened then is an international history. On her way to Lyon on 27 July 1976 the plain was hijacked to Entebbe were they were imprisoned and saved by Israeli Special force 4 July the bicentennial of United States (4 July 1776) the rescue by the Israeli Army Forces is documented by the video which may be found in a link https://www.youtube.com/watch?v=wWc01bnKMow&list=UUZT-dcVM0XYnXShFLiI82gw.

Research group of Professor Renata Reisfeld is shown in Fig. 2.

Fig. 2. Professor Reisfeld research group: center - Renata Reisfeld, right - researcher Viktoria Levchenko, left - researcher Tsiala Saraidarov.

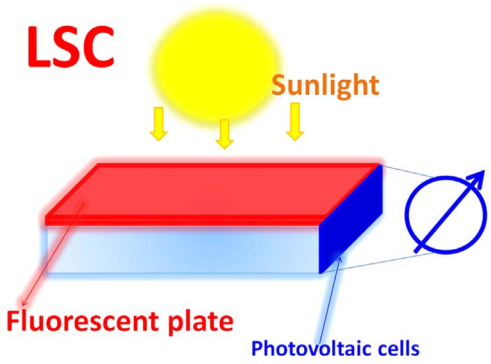

Fig. 3. The scheme of LSC.

1. Introduction

Luminescent Solar Concentrator (LSC) consists of luminescent plate excited by solar light which is concentrated on the plate edges. The concentration of light decreases the cost of the photovoltaic electricity by using much smaller amount of costly photovoltaic cells [1].

The principal scheme of LSC is shown in Fig. 3.

The idea of LSC has been proposed several decades ago [1–6]. Limitations to produce effective stable LSC still exist and these have to be improved [7–16].

The excitation of surface plasmons (SPs) in metallic nanoparticles (NPs) induces optical properties hardly achievable in optical materials, yielding a wide range of applications in many fields such as biomedicine, energy, environment protection and information technology [3].

Specifically the phenomena of increasing the lanthanides fluorescence by SPs of silver and copper NPs have been described in papers [17–20]. Here we present the additional information of increasing the luminescence of the chelate complex of Europium by SPs of gold NPs.

The luminescence of trivalent lanthanide ions has found applications in lighting, lasers, optical telecommunications, medical diagnostics, and various other fields.

The basic theory of lanthanide spectroscopy is summarized in the recent paper [3].

The possibility to additional increase the luminescence of EuEDTA complex by gold NPs will extend the present applications.

In this paper we present new results of preparation of complex of Europium EDTA incorporated in organically modified siloxane matrix and co-doped by AuNPs.

2. Experimental

The experimental part consist the following stages:

1. Preparation of ormosils matrix GPSPU solution (solution 1)
2. Gold NPs formation process (solution 2)
3. GPSPU matrix solution doped by EuEDTA (solution 3)
4. GPSPU matrix solution doped by EuEDTA and Gold NPs

2.1. Preparation of ormosils matrix GPSPU solution (solution 1)

For coating of optical clear glass material based on organically modified siloxanes (ormosils) and formed by a sol-gel process is prepared. The matrix is named as GPSPU (abbreviation was obtained from precursors) and prepared with following molar ratio of precursors: glycidoxypropyl-trimethoxysilane (Glymo)/phenyl tri-methoxy silane (PhTMOS)/tetraethoxysilane (TEOS)/poly-urethane-siloxane (PUS) = 1.0/1.0/3.0/0.45/ which were mixed in a propanol/phenoxy-ethanol solution. The solution was hydrolyzed using water and an acetic acid solution, stirred at room temperature 20 °C for 24 h, filtered and kept in refrigerator.