In the name of God

H_2 and Fuel Cells:

Overview of Current Research Activities

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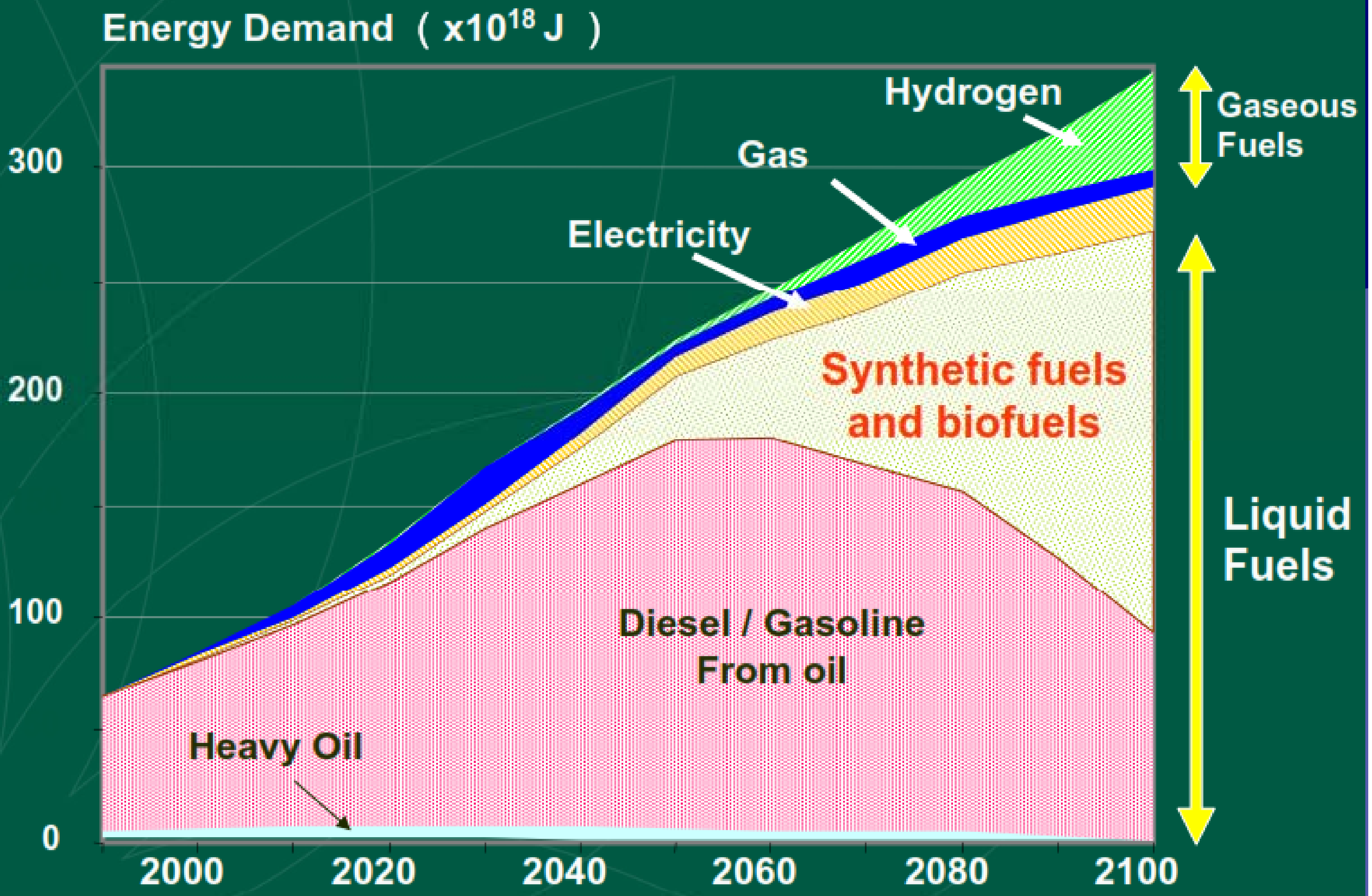
Outline

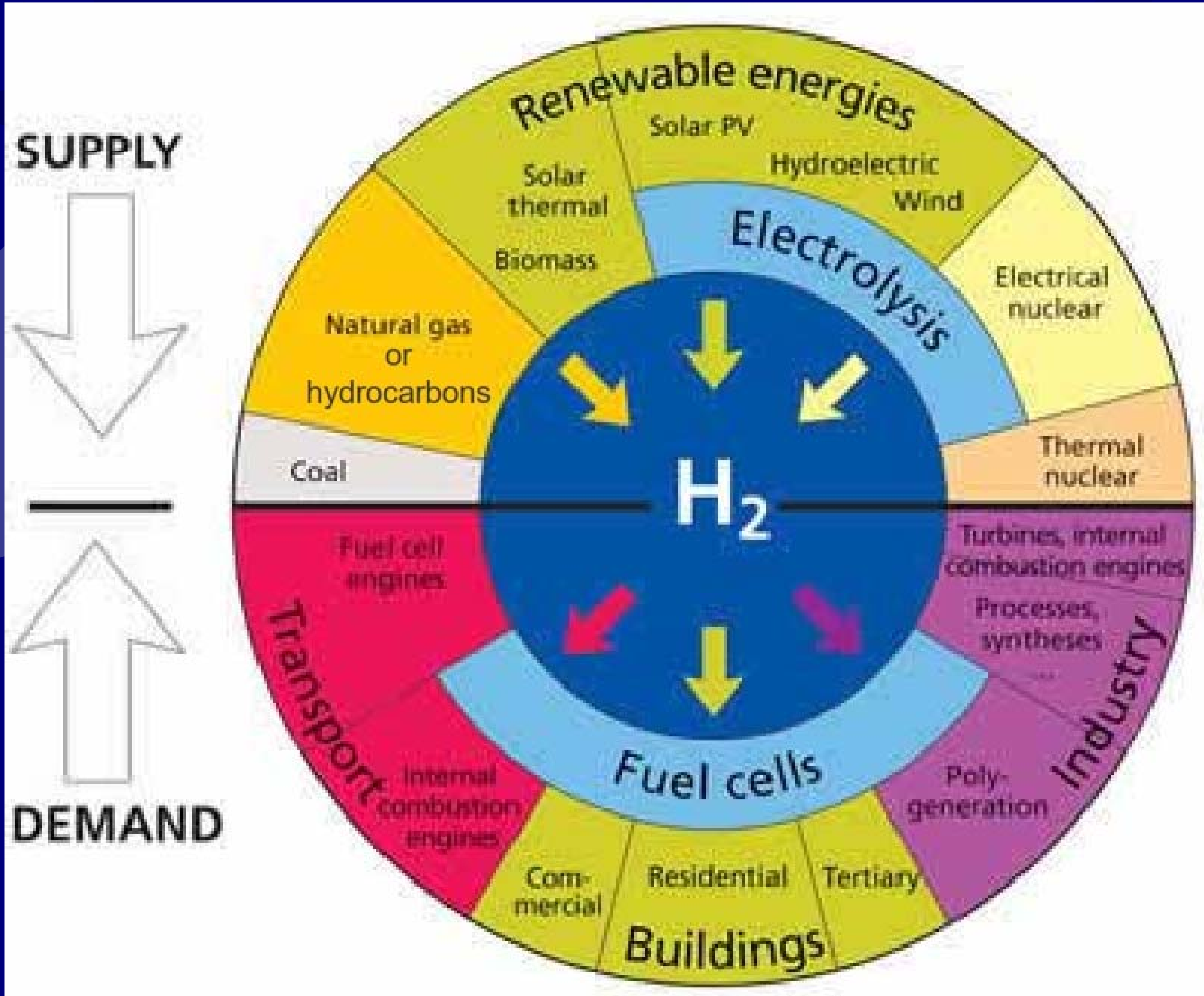
1. Introduction
2. H_2 and Fuel Cells in IROST
3. Potentials for Cooperation

Energy Demand



Source: IEA

Hydrogen Supply and Demand



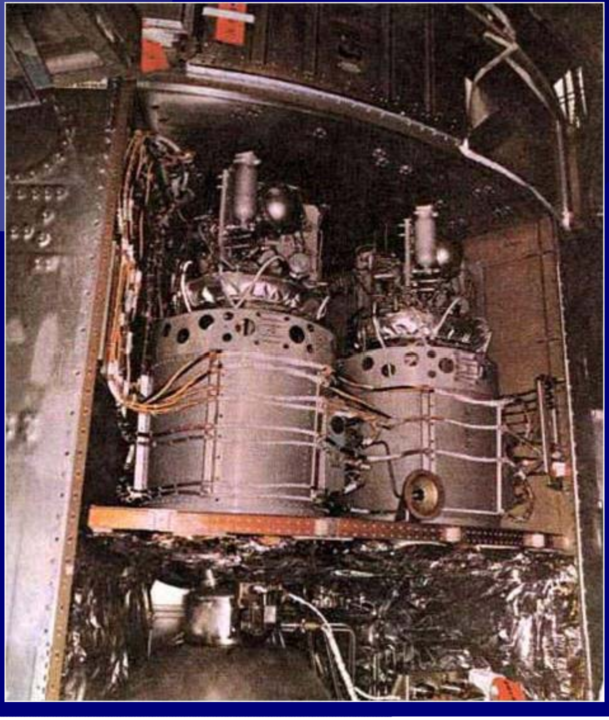
Fuel Cell History

- In 1955, GE Co. modified the original FC design.

- GE went on to develop this technology with NASA and McDonnell Aircraft, leading to its use during Project Gemini. This was the first commercial use of a fell cell.

- In the 1960s, Pratt and Whitney Co. licensed some U.S. patents for use in the U.S. space program to supply electricity and drinking water.

1.5 kW FC in APOLLO Project (1969)




FUEL CELL


TOYOTA
FCHV-F
FUEL CELL HYBRID VEHICLE

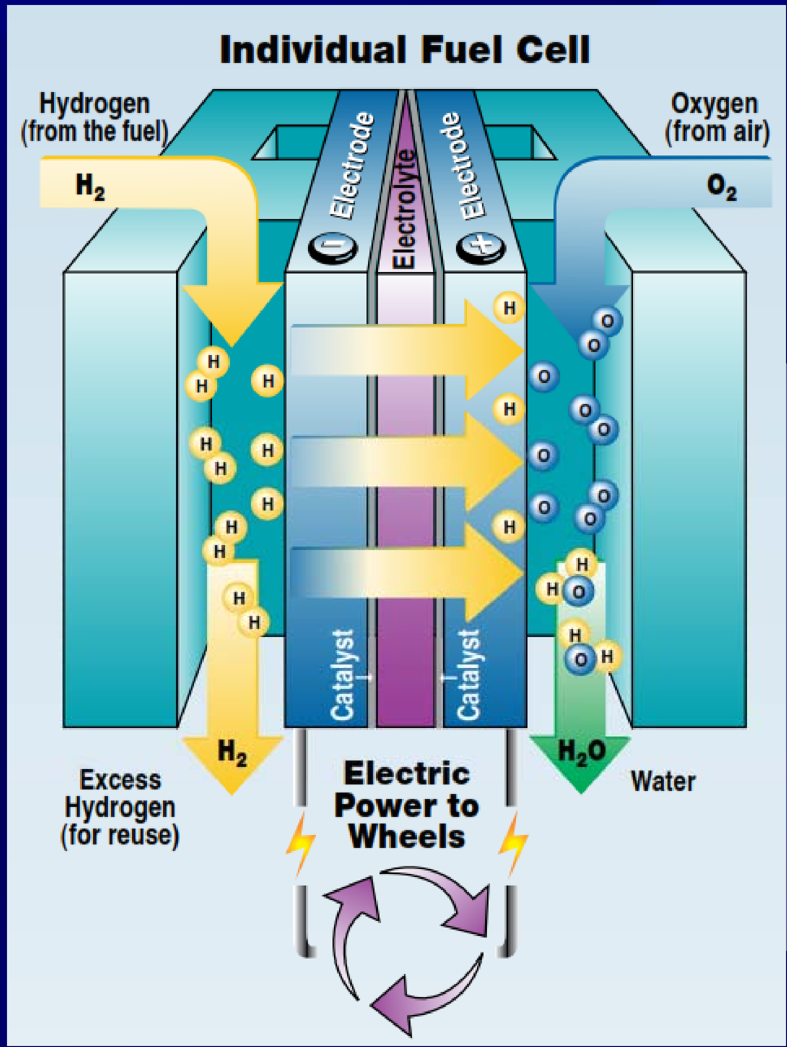

DMFC
TOSHIBA

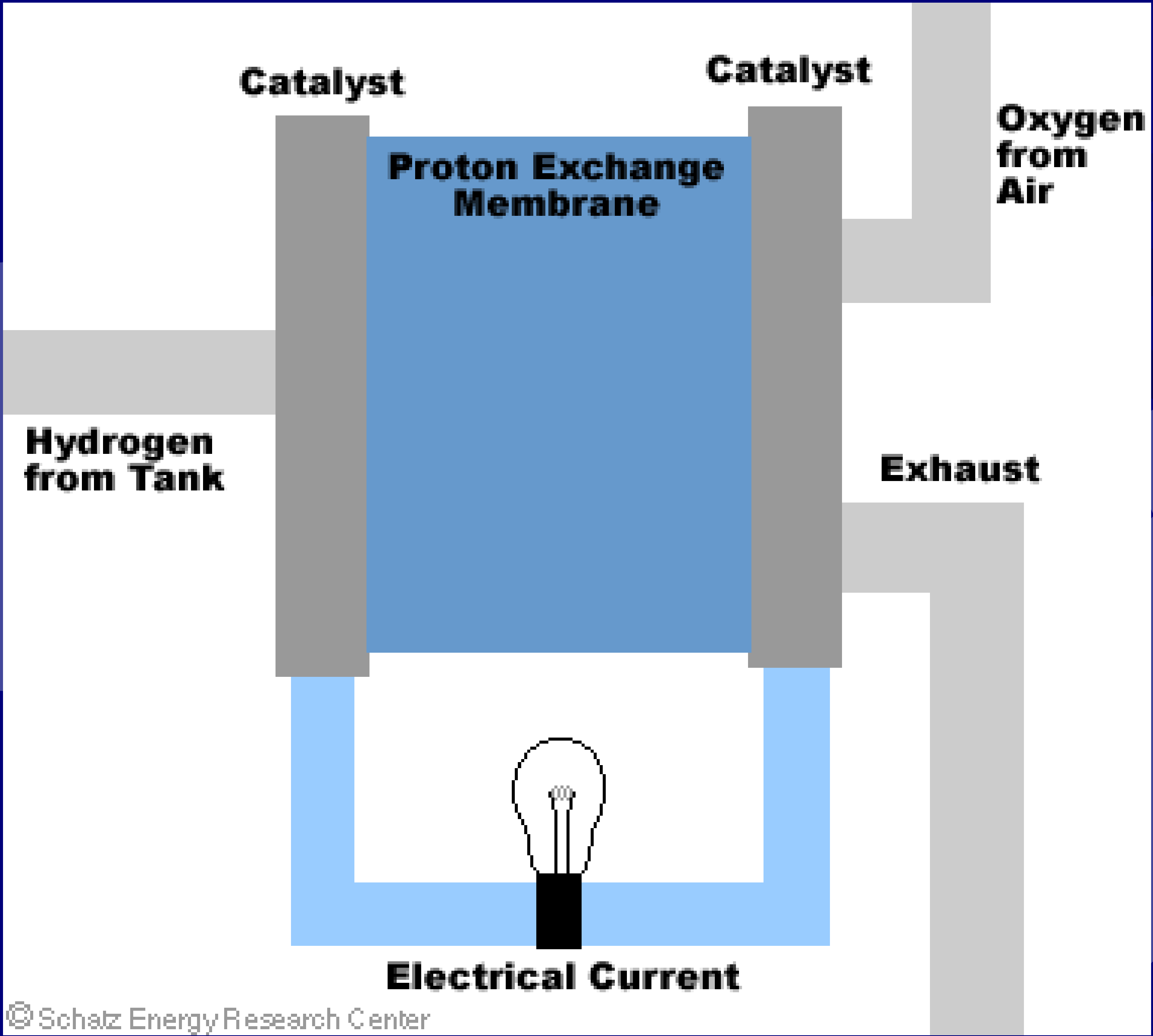

Fuel Cell Bus
London Bridge Tate Modern Waterloo
Covent Garden
RV1
ESQ64991
CITARO
LK53 MBO

Renewable Energy Exposition, May 2013, Tehran, Iran

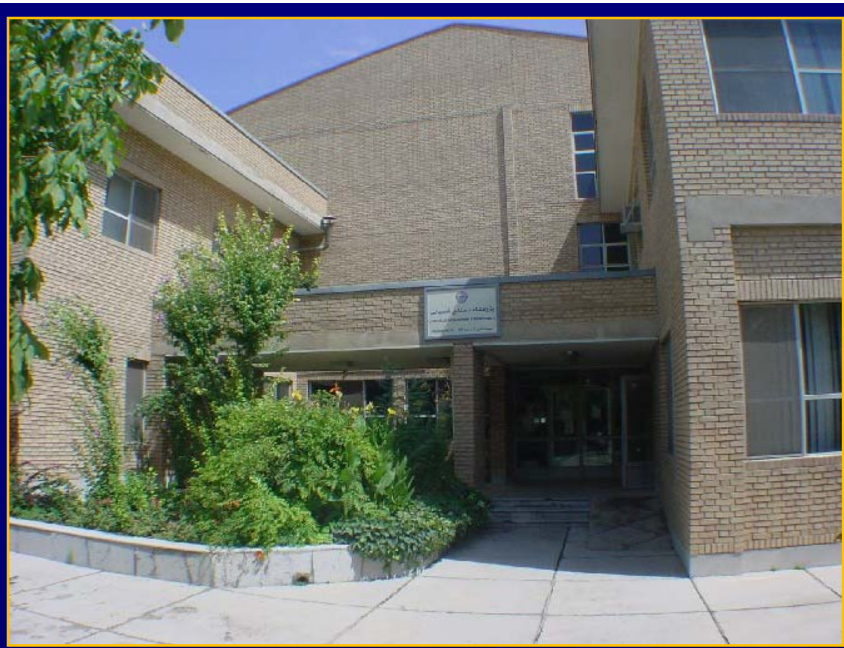
Proton Exchange Membrane (PEM)

- This is the leading cell type for passenger car application
- Uses a polymer membrane as the electrolyte
- Operates at a relatively low temperature, about 80°C
- Has a high power density




Catalyst
Catalyst
Oxygen from Air
Proton Exchange Membrane
Hydrogen from Tank
Exhaust
Electrical Current
© Schatz Energy Research Center

Inst. of Chemical Technology



H_2 and FC Technology Center

In 2010, H_2 and FC technology development was started by Inst. of Chem. Tech. at IROST.

H_2 and FC Technology Center

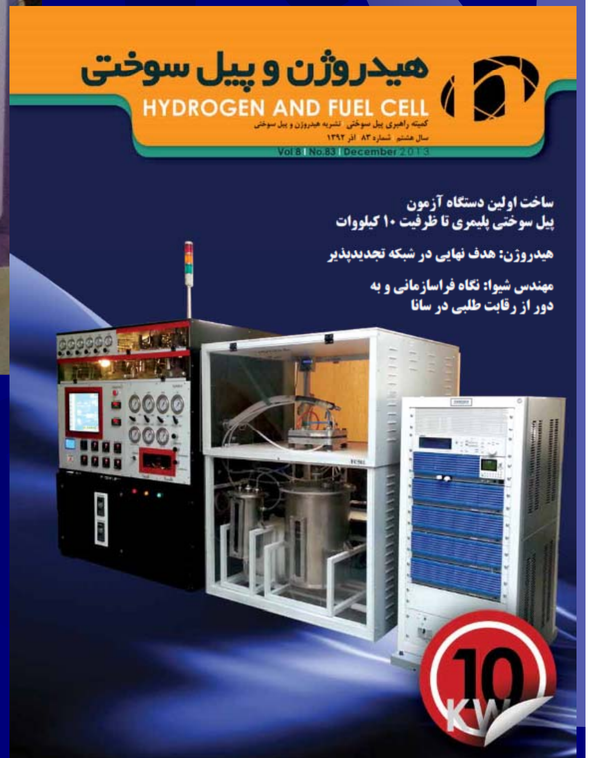
Broad range of research activities are already in progress:

- *Fuel Cell Test Station (PEM / MeOH / SOFC)*
- *MEA fabrication for PEM Fuel Cells*
- *SOFC Raw Materials*
- *Fuel Processing Systems*
- *H_2 Storage Technologies*

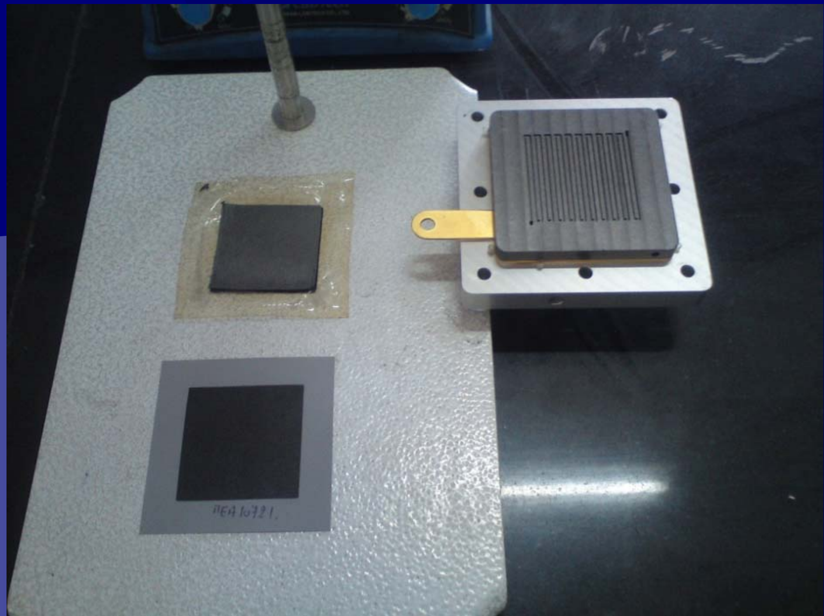
IROST-300: A PEM Fuel Cell Test Station

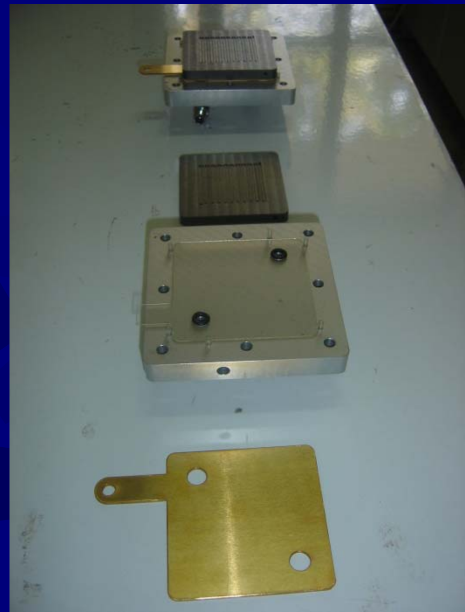
IROST-10 kW: A PEM / MeOH Fuel Cell Test Station

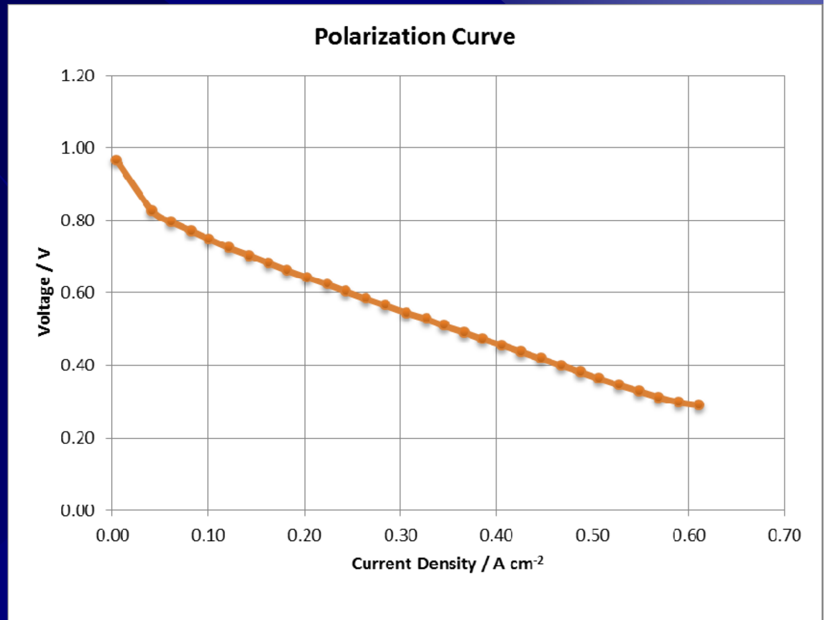
Sci. & Tech. Expo,
Nov. 2013,
Tehran, Iran



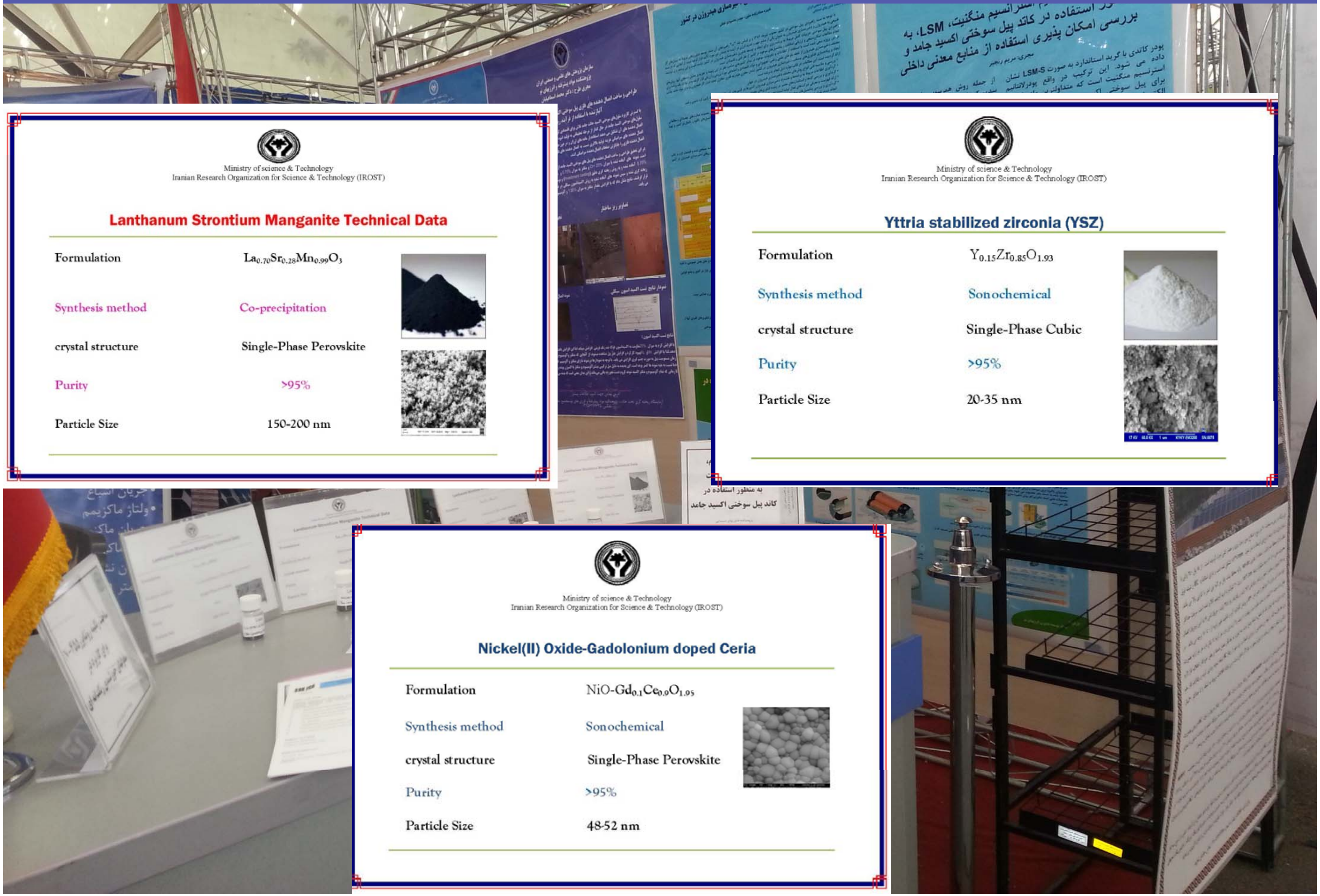
MEA Fabrication for PEM FCs







Solid oxide Fuel Cells Products



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Iranian Research Organization for Science & Technology (IROST)

Lanthanum Strontium Manganite Technical Data

Formulation	$La_{0.70}Sr_{0.28}Mn_{0.99}O_3$
Synthesis method	Co-precipitation
crystal structure	Single-Phase Perovskite
Purity	>95%
Particle Size	150-200 nm

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Iranian Research Organization for Science & Technology (IROST)

Yttria stabilized zirconia (YSZ)

Formulation	$Y_{0.15}Zr_{0.85}O_{1.93}$
Synthesis method	Sonochemical
crystal structure	Single-Phase Cubic
Purity	>95%
Particle Size	20-35 nm

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Nickel(II) Oxide-Gadolonium doped Ceria

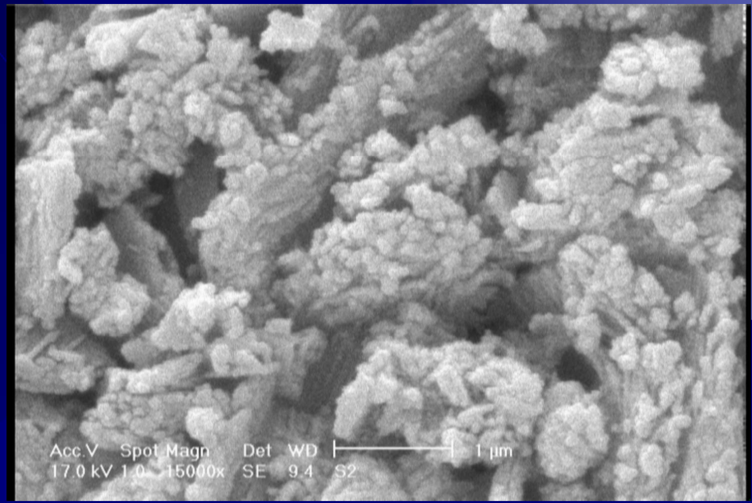
Formulation	$NiO\text{-}Gd_{0.1}Ce_{0.9}O_{1.95}$
Synthesis method	Sonochemical
crystal structure	Single-Phase Perovskite
Purity	>95%
Particle Size	48-52 nm

Fuel Reforming Technologies

NG reformer for
H_2 and syngas production

MeOH reformer
for H_2 and DME production

SEM images of a synthesized catalyst for
hydrogen production from methanol
steam reforming



Thin Layer and Nanotechnology Lab.

- Thin Film Based Sensors and Biosensors
- Preparation of Electro-catalyst Layer of Pt Nanoparticles for PEMFC
- Fabrication of Dye sensitized Solar Cell
- Thin Film based Smart Windows

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HYDROGEN & FUEL CELL

Theoretical study of the effect of hydrogen addition to natural gas-fueled direct-injection engines

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Abstract

The preparation of air–fuel mixture to achieve improved performance, efficiency, and engine combustion is considerably dependent on fluid flow dynamics. In this study, the effects of mixtures of hydrogen and compressed natural gas (CNG) on a spark ignition engine are numerically considered. This article presents the results of a direct-injection engine using methane–hydrogen mixtures containing 0 and 15 vol.% H_2. The results show that the percentage of hydrogen in the CNG increases the burning velocity of CNG and reduces the optimal ignition timing to obtain the maximum peak pressure

H_2 and FC Staff

Making H_2 Storage Tanks in IROST

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Original Article

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Mechanical performance of epoxy/carbon fiber laminated composites

Hossein Rahmani, S Heydar Mahmoudi Najafi and Alireza Ashori

Abstract

The objective of this research work was to gain a better understanding of the mechanical properties of epoxy resin composites reinforced with carbon fiber. For this purpose, the effects of fiber orientations, resin types, and number of laminates on mechanical properties of laminated composites have been investigated. In the sample preparation, composites were manufactured by hand lay-up process, using a fiber-to-resin ratio of 40:60 (w: w). To investigate the effect of fiber orientation, angles of 0°, 35°, 45°, and 90° were selected. Results show that the mechanical properties, in terms of tensile, flexural and impact strength, were mainly dependent on the fiber orientations followed by the number of laminates. At a similar fiber orientation, the composites made with EM500 epoxy resin showed the highest mechanical properties (such as tensile and flexural and impact strengths) compared to other evaluated composites. However, the differences were not highly significant. The results indicated that the mechanical properties of composites made with five-ply were generally slightly greater than three-ply composites. It may be due to the bondline defects, which adversely influence the mechanical properties. Scanning micrographs of the composites showed that the epoxy matrix material was fully adhered to the fibers, indicating a strong interface. It can be concluded that the order of increment parameters in the mechanical properties of the composites is fiber orientation > number of laminates > resin type. In addition, the tensile and flexural properties were superior in case of ±35° fiber orientation.

Keywords

Laminated composites, fiber orientation, epoxy resin, carbon fiber, mechanical properties

Mechanical Properties of Carbon Fiber/Epoxy Composites: Effects of Number of Plies, Fiber Contents, and Angle-Ply Layers

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Multi-axial multi-ply fabric (MMF) composites are becoming increasingly popular as reinforcing materials in high-performance composites due to their high mechanical properties. This work aimed to study the effects of three variable parameters including fiber contents, numbers of plies, and layer orientations on the mechanical properties of MMF composites. Unidirectional carbon fibers and a two-part epoxy resin were employed to produce the composite laminates using the manual lay-up process. It was found that the mechanical properties of composites made with 5-ply were slightly greater than 3-ply composites. However, there was no highly significant difference between them. Generally, the angle-ply of the composites showed the greatest effect on the mechanical properties compared with number of plies and layer orientations. The significant improvements in mechanical properties of the composites were further supported using scanning electron microscopy (SEM). Morphologies of the tensile fracture surfaces of composites revealed that the presence of fiber pulled out results in the creation of voids between the fibers and matrix polymer. This causes the mechanical properties of the composites to be reduced. Finally, the enhancement of mechanical properties of composites clearly confirmed that angle-ply layer (0°,−35°,0°,+35°,0°) had the most significant reinforcing effect among other parameters evaluated. POLYM. ENG. SCI., 00:000–000, 2013. © 2013 Society of Plastics Engineers

INTRODUCTION

In an attempt to improve the physico-mechanical properties of carbon fiber reinforced plastics, while reducing manufacturing costs and weights, new generation of composites are being developed. The so-called noncrimp fabric (NCF) materials respond to this demand [1]. NCF, often referred to as multi-axial multi-ply fabric (MMF), is a class of composite materials, made with layers of unidirectional plies at different angles, which holds the plies together allowing some light degrees of freedom among adjacent plies [2]. In contrast with fabrics, NCFs are fiber layers without crimp, providing higher mechanical properties due to fiber alignment and higher volume fraction of fibers. Composites based on MMFs can be made by traditional lamination, pultrusion, and especially resin transfer molding [3]. These composites are obtained by stacking blankets, which are typically made up from two to five layers of fibers stitched together through their thickness. This process is represented in Fig. 1 where it can be seen that the layers, which can be oriented in several directions, are made up of tows of fiber placed side by side [4]. The basic mechanical properties of the investigated NCF/epoxy composites were found very competitive as compared either to unidirectional prepreg tape laminates or to woven fabric laminates with similar technological characteristics. However, the main drawback associated with the stitching process is the heterogeneity at the scale of the tows, which is attributed to fibers breakage caused by the introduction of needles into the tows used for the penetration of the stitching within the plies, as well as to imperfections between tows, such as resin poor areas known as "resin pockets" [5]. It should be noticed that, so far, NCF composites are based on thermoset matrices. As a consequence, the available information in the open literature about both, experimental investigations [6, 7] and also modeling approaches for relating the NCF mechanical properties to their constituents' characteristics [8, 9], refer solely to thermoset composites.

The majority of engineering composite materials in service consist of continuous fibers of carbon, or glass, reinforcing an epoxy polymeric matrix. The carbon fiber is one of the most used materials for the preparation of large varieties of composites. They present unique advantages in terms of strength-weight relation, and can influence the physical and mechanical properties through the form, orientation, and content modification [6]. In structural applications, such as aircraft primary structures, excellent mechanical properties are expected. Thus, the extent of matrix and reinforcement adhesion is very important, since the adhesive force affects the thermal and mechanical strength, modulus, stiffness, and fracture behavior of the polymer composites [10]. On the other side, epoxy resin has been of significant importance to the engineering community for many years. Components made of epoxy-based materials have provided outstanding thermal and electrical properties [11]. The epoxy, when polymerized, is an amorphous and a highly cross-linked material. This microstructure of the epoxy polymer results in many useful properties such as high modulus and failure strength, low creep, etc., but also leads to an undesirable property in that it is relatively brittle and has a relatively poor resistance to crack initiation and growth [12].

Accordingly, the primary purpose of this work was to prepare carbon fiber/epoxy MMF composites on laboratory scale. The effects of number of plies, angle-ply laminates, and fiber contents on some mechanical properties of the resulting laminate composites were investigated.

EXPERIMENTAL

Materials

Unidirectional carbon fiber, Toray's Torayca T700S-12k, was employed to lay-up composite laminates as reinforcing agent.

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Books

1. Saffarzadeh Matin, Sh, & Mahmoudi Najafi, H. "*Hydrogen Storage Technologies.*" Published by IROST, 2014.
2. Ranjbar, M. "*Solid Oxide Fuel Cells.*" Published by IROST, 2014.
3. "*PEM Fuel Cell Testing and Diagnosis.*" Translated by Dr Nahid Khandan.

Potentials for Cooperation

- Production of in-situ electrochemical equipments (e.g. EIS) for upgrading IROST Test Stations
- Developing new MEAs and SOFC anode/cathode materials fabrication technologies through carrying out Sci. & Tech. workshops
- Developing new reforming technologies
- Chemical Hydrogen Storage

Thank you.