Annexure-II

Description of Technology

Thermally cyclable glass composition for intermediate temperature solid oxide fuel cell (SOFC):

Background:

Solid oxide fuel cells (SOFCs) are the most promising and emerging technology compared to other available power technologies because of their high efficiency, in terms of power and thermal management, and fuel flexibility. The SOFCs are classified into three types based on their operating temperature: (i) low temperature (500-700^{o}C), (ii) intermediate temperature (800-1000^{o}C), and (iii) high temperature (>1000^{o}C). Manufacturing of SOFC stacks at commercial level still faces the strenuous task of gastight sealing because rapid degradation of the cell performance is observed when small leaks are present. Thus, sealing technology is an important issue with respect to commercialization of intermediate temperature SOFC-based power generators. Among the various types of sealant materials, glass and glass-ceramic (GC) materials are considered as the most efficient and attractive sealing materials for SOFCs due to their ability to form durable hermetic seals at high temperatures, low costs and durability. A principal advantage of the glass seals is that their chemical composition and molecular structure can be tailored to optimize properties like coefficient of thermal expansion (CTE), mechanical strength, sintering behavior, chemical and electrical resistance, etc. However, a major issue with these seals is related to their long-term chemical and thermal stability. The barium-rich alumina-silicate based glass seals are known to exhibit appropriate CTE and sintering behavior required for their operation in SOFCs. However, these glasses tend to devitrify at 800-850°C resulting in the appearance of hexacelsian ($BaAl_2Si_2O_8$) crystalline phase in the GC which during gradual SOFC operation transforms into its monoclinic polymorph with low CTE, lowering the CTE values for the GC seal along with deterioration of its mechanical properties. Similarly, severe chemical interactions have been observed at the interface between BaO-containing and alkali containing glass seals when joined with metallic interconnect of SOFC. A vast amount of literature available in this area depicting the failure of glass seals during long-term operation warrants a thorough investigation of long-term thermal and chemical stability of any proposed glass composition for high temperature sealing application.

In this pursuit, the thermal stability study of lanthanide (Ln = La, Nd, Gd, Yb) containing BaO and alkali-free glass and glass-ceramics (GCs) is focused upon investigating the long-term (up to 1000 h) thermal and chemical stability. However, thermal stability along with cyclability is still pending. Therefore, this is very important to address these issues by developing suitable glass compositions and GCs, and to prove their suitability as sealing materials for SOFCs.

Description of technology:

In view of above, we have developed the BaO and alkali oxide-free glass composition for SOFC stacks in CaO-SrO-B_2O_3-SiO_2-P_2O_5 glass systems. The developed glass composition possesses the following properties

- The thermal stability: Up to 1000 h
- Cyclability (25°C -800°C -25°C): 20 cycles
- The glass sealant is capable of making a hermetic seal for both metal-metal and metal-ceramic interfaces
- The glass composition is devoid of any toxic raw materials (e.g., PbO, CdO, etc.) which are often used in glass industry.

Table 1: List of Equipments required

Sl. No.	Name of the equipment
1.	Raising hearth type glass-melting furnace (Maximum temp. 1600^{o}C)
2.	Platinum/Platinum-Rhodium crucible
3.	Mortar grinder
4.	Sieve shaking machine

Table 2: List of Raw materials required

Sl. No.	Name of raw material
1.	Calcium carbonate
2.	Strontium carbonate
3.	Aluminium oxide
4.	Titanium oxide
5.	Boric acid
6.	Quartz
7.	Nickel oxide
8.	lanthanum oxide
9.	Cerium dioxide
10.	Phosphoric acid
11.	Terpineol
12.	Ethyl cellulose