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A Review on Performance Anyalysis of Different Desiccant Materials for a Desiccant Cooling System

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Abstract

Performance of desiccant plays a crucial role in overall performance of the whole system, especially in terms of dehumidification and regeneration capacity. This review summarizes recent researches and developments on novel solid desiccant materials that can be adopted in SDC systems. This paper presents includes behavior of mono materials silica gel, zeolite and polymer and the composite materials which are based on silica gel, based on Mesoporous silicate, based on Aero gels at different regeneration temperature and RH. It also includes the comparison of the performance of silica gel and composite desiccant material at different ambient temperature. The results demonstrated that the composite adsorbents can be a good candidate for low temperature heat-driven adsorption cooling and dehumidification systems.

Keywords: *desiccant material, Silica gel, Composite desiccants, Mesoporous silicate, Aero gel*

I. INTRODUCTION

We all live in the era of the energy crises. It is very necessary for all of us to save the energy or produce the new source of the energy. All around the world, maximum energy utilized by the industries for the cooling purpose. So it is our duty to find out the new scope/way of the cooling technique over the conventional cooling system. Desiccant material is widely used in various fields according to the working condition and requirement. Different types of desiccant materials use in the pharmaceutical industry. Here, We are discussing on the desiccant material for the desiccant cooling system. Working principle of the desiccant cooling system is dehumidification and evaporative cooling. The main advantage of the system is that, latent load and sensible load controlled individually. The word desiccant material is representing the "moisture absorbing material." Higher the moisture absorbing capacity, indicate the higher COP of the system.

From the last decades, air conditioning industry face challenges for developing a new cooling technique, over a conventional VCR (Vapor Compression Refrigeration) system. Desiccant cooling system have more advantages over a conventional VCR system as described below.

1. Low grade energy is use to operate SDC, like non-conventional sources.(e,g- solar energy, geothermal energy), so we can able to save a huge energy.
2. In desiccant cooling system, water is used as a material of refrigerant, and most of the desiccant materials are eco-friendly.
3. Desiccant cooling system has lower operating cost as compare the VCR.
4. Vapor conventional system is handle the air at 4 ^{0}C (dew point temp) while desiccant cooling system can be handle the air at -40 ^{0}C (dew point temp).

II. TYPES OF DIFFERENT DESICCANT MATERIALS.

With progress in the material science, various new types of solid and liquid desiccant material are introduced and research going on that materials. Research is going on to develop new advance material with improved moisture adsorption capacity, regeneration capacity and its stability.

There are mainly two types of desiccant material according to their phase. (i) Liquid desiccant material (ii) Solid desiccant material.

According to the various researchers, we can able to say that, solid desiccant cooling system is more reliable as compare to liquid used desiccant cooling system. Handling of the desiccant material is easy in the solid desiccant cooling system as compare the liquid desiccant cooling system.

2.1. Low regeneration temperature desiccant materials[1]:

Typically, silica gel is used as a desiccant material in a desiccant cooling system. Regeneration temperature of silica gel is quite high. So that, it is important to find out the alternate of the silica gel, which satisfied all the condition of the desiccant cooling system. Zeolite is one of the optional material used as a desiccant. The Comparison of the silica gel, zeolite, and polymer wheel are given below. Dehumidification performance of the silica gel, zeolite and super adsorbent polymer is graphically shown in fig.1

1. The moisture adsorption capacity increase with increasing relative humidity (RH).
2. Silica gel, is more suitable in all condition as compare to zeolite. But at higher RH, they both give same performance.
3. The performance of the super adsorbent polymer is more than silica gel at lower regenerating temperature (50 ^{0}C) and at higher RH (>50 % at 30^{0}C)

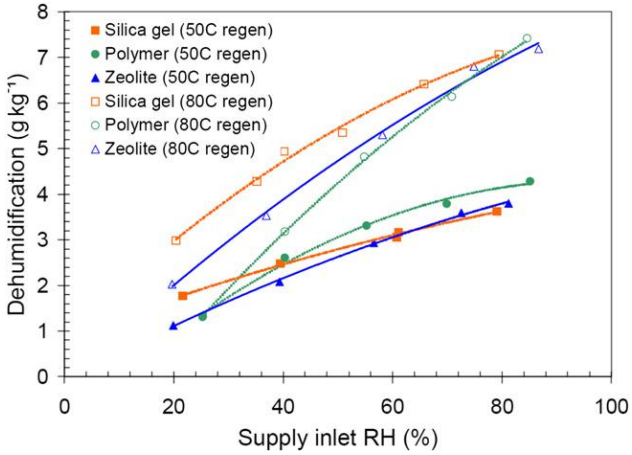

Fig.1

2.2. Composite Desiccant:-

In the recent years, the composite desiccant materials are frequently used, as compared the individual material. They are formed by impregnating salt of hygroscopic to pores of porous desiccant material. Silica gel and meso- porous silicate are the conventional porous desiccant material. They have the advantages of the lower cost and stable characteristics. On other hand, the disadvantage is that, low adsorption capacity leads to big size of the desiccant cooling unit.

Silica gel based composite and meso-porous silicate based composite material are discuss below.

2.2.1. Composite based on Silica gel

Silica gel is the most widely used as a host of other desiccant material. This is because of its, lower cost and lower regeneration temperature. LiCl, LiBr, KSK, $CaCl_2$ are the different material, those are composite with silica gel. Adsorption capacity of the SG/LiCl composite was 2 to 3 times higher than pure silica gel at higher RH. From the researchers result analysis , we can say that, under actual operating condition the adsorption capacity of the composite desiccant wheel is increased by 20 to 40 %, compared to conventional silica gel. Various combination of the different desiccant material and its adsorption capacity shown in the fig.2**.**

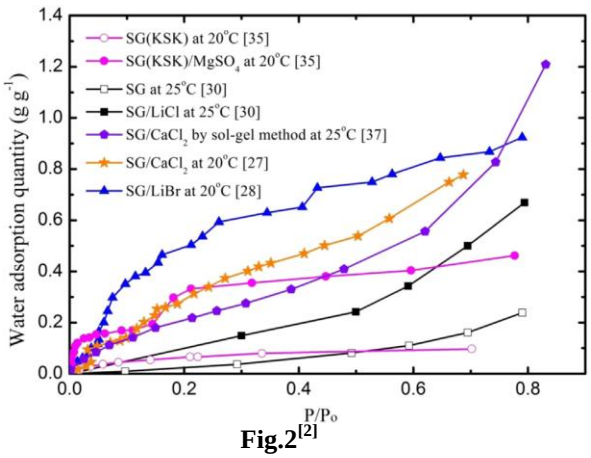

Fig.2[2]

2.2.2 Mesoporous silicate based composite:

By hydrothermal formation of the silica gel, a new group of order silicate of mesoporous are prepared. Mesoporous silicate gives better performance in terms of adsorption capacity over a simple silica gel. It can be seen that, with narrow pore size distribution, synthetic mesoporous silicate can not only be adopted as desiccant material but also be adopted as host materials within composite desiccant. Performance of the mesoporous silicate based composite are shown in the fig.3. [3,4,5,6]

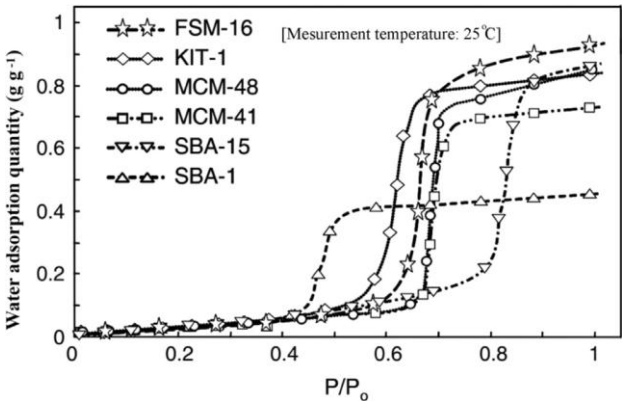

Fig.3

2.2.3 Aerogels

Aerogels materials are formed by a sol-gel synthesis and drying of the gel. Porous nanostructured material with approximate 90 to 99% air by volume, is called an aerogel. Due to the high porosity and higher surface area, the ability of the adsorbent of the water vapor and gases are higher. Different types of the aerogel materials are: silica aerogel, alumina oxide aerogel, silica oxide aerogel etc. Adsorption capacity of the silica aerogel is approximate 1.35 g/g. Water adsorption capacity of the carbon aerogel is also high as like a silica gel aerogel. Performance in terms of water adsorption capacity of different aerogels materials are shown below. [7,8,9,10]

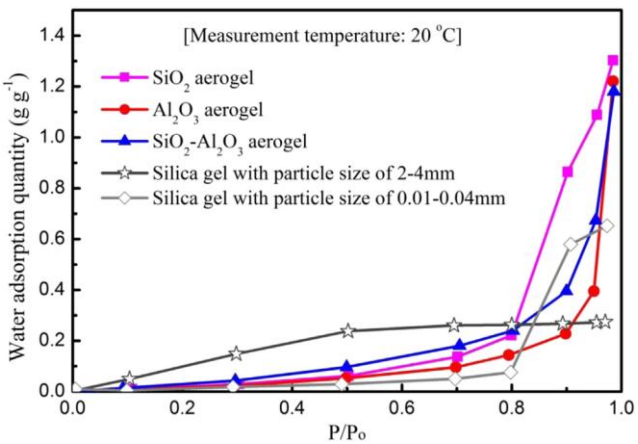

Fig.4

2.2.2. 2.2.4 Performance comparison of silica gel and composite material[11]

The comparison between regular silica gel, and from composite desiccants given at different supply air temperature at different relative humidity is given in the form of adsorption capacity. It is seen that the new composite desiccant.

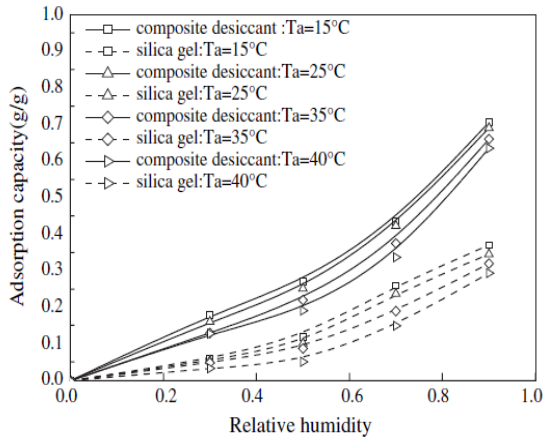

Fig.5

wheel can remove more moisture from the air, about 40e50% higher over the silica gel one, indicating a better performance for using new materials at the rotation speed of 12 r/h. In the analysis, the Nusselt number and the Sherwood number are both taken as 20, which agree with the experimental observation in this study

III. CONCLUSION

From above all discussion, one can able to conclude following listed points.

1. Compound desiccant material gives better performance over a single desiccant material.
2. Adsorption capacity of the same material is different at different RH.
3. Adsorption capacity of the material is also depend on the pore size of that material.
4. Regeneration temperature of the material is also a major parameter of selection of the materials.

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