EXPERIMENTAL INVESTIGATION ON PROPERTIES OF OXIDES

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ABSTRACT

Oxides are a diverse group of materials with magnetic, dielectric, photocatalytic, and optical characteristics, making them potentially valuable in a wide range of applications. Oxides come in a wide range of shapes and sizes, and they may be found in a wide range of environments, from geological to nanoscale technology applications. Oxide materials in bulk and thin films, as well as metal oxide nanostructures, have a wide range of functional characteristics, making them excellent for solar cells, gas sensors, optoelectronic devices, passive optics, catalysis, corrosion prevention, and environmental protection, among other uses. The many features of oxide are investigated in this study. Structure and kinds of oxides were also investigated.

Keywords: Material, Film, Oxide, Material, Metal, Synthesis.

I. INTRODUCTION

Some oxides can generate an acidic, basic, or amphoteric solution when they come into contact with water. A substance that can react chemically as either an acid or a base is known as an amphoteric solution. It is conceivable, however, for an oxide to be neither acidic nor basic. The three types of oxides can be distinguished by their various qualities. Anhydride (meaning "without water") refers to substances that absorb H_2O to generate an acid or a basic when water is added. Oxides are oxygen-containing binary compounds with another element, such as CO_2, SO_2, CaO, CO, ZnO, BaO_2, H_2O, and so on. Because oxygen is combined with only one element, these are referred to as oxides. Oxides are classed as acidic or basic based on their acid-base properties. Acidic oxide is an oxide that forms an acid when it reacts with water. A basic oxide is an oxide that produces a base in water.

Types Of Oxides

Oxides are characterised as acidic, basic, amphoteric, or neutral based on their acid-base characteristics:

1. An acidic oxide is an oxide that reacts with water to form an acid.

2. A basic oxide is an oxide that produces a base in water.

3. An amphoteric solution is one that can react chemically as an acid or a base.

4. However, an oxide can be neither acidic nor basic, and so is referred to as a neutral oxide.

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Acidic Oxides

Acidic oxides are non-metal oxides, and these acid anhydrides react with water to generate acids.:
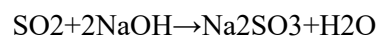
Sulfurous Acid

$$SO_2 + H_2O \rightarrow H_2SO_3$$

Sulfuric Acid

$$SO_3 + H_2O \rightarrow H_2SO$$

Carbonic Acid
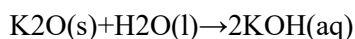
$$CO_2 + H_2O \rightarrow H_2CO_3$$

Acid anhydrides are acidic oxides that generate salts when associated with bases (e.g., sulphur dioxide is sulphurous anhydride and sulphur trioxide is sulfuric anhydride), e.g.,
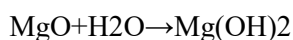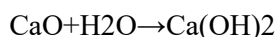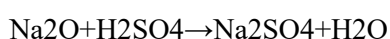
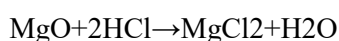$$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$$

Basic Oxides

Generally Group 1 and Group 2 elements form bases called base anhydrides or basic oxides e.g.,

$K_2O(s)+H_2O(l)\rightarrow 2KOH(aq)$

Metal oxides are called basic oxides. They react with water to form hydroxides if they are soluble in water. (alkalies) e.g.,
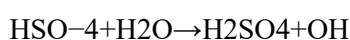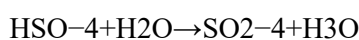
$CaO+H_2O\rightarrow Ca(OH)_2$

$MgO+H_2O\rightarrow Mg(OH)_2$

$Na_2O+H_2O\rightarrow 2NaOH$

These metallic oxides are known as basic anhydrides. They react with acids to produce salts, e.g.,

$MgO+2HCl\rightarrow MgCl_2+H_2O$

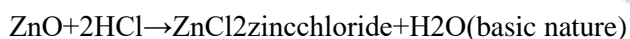$Na_2O+H_2SO_4\rightarrow Na_2SO_4+H_2O$

Amphoteric Oxides

A substance that can react chemically as either an acid or a base is known as an amphoteric solution. When HSO_4^- interacts with water, for example, it produces both hydroxide and hydronium ions:

$HSO_4^-+H_2O\rightarrow SO_4^{2-}+H_3O$
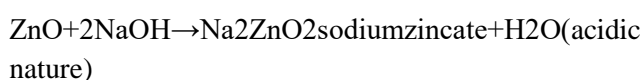
$HSO_4^-+H_2O\rightarrow H_2SO_4+OH$

Both basic and acidic characteristics are found in amphoteric oxides. They produce salt and water when they react with an acid, demonstrating basic characteristics. When alkalies react with them, they produce salt and water, both of which have acidic qualities.

For example, ZnO exhibits basic behavior with HCl

$ZnO+2HCl\rightarrow ZnCl_2 zinc chloride+H_2O$(basic nature)

and acidic behavior with NaOH

$ZnO+2NaOH\rightarrow Na_2ZnO_2 sodium zincate+H_2O$(acidic nature)

Similarly, Al2O3 exhibits basic behavior with H2SO4

$Al_2O_3+3H_2SO_4\rightarrow Al_2(SO_4)_3+3H_2O$(basic nature)

and acidic behavior with NaOH

$Al_2O_3+2NaOH\rightarrow 2NaAlO_2+H_2O$(acidic nature)

Neutral Oxides

Neutral oxides, such as carbon monoxide (CO), nitrous oxide (N2O), nitric oxide (NO), and others, have neither basic nor acidic characteristics and hence do not produce salts when reacting with acids or bases.

II.   THE GEOMETRIC STRUCTURE OF OXIDE SURFACES

We can build oxide surfaces in principle by cutting the crystal along any crystal plane, starting with a three-dimensional bulk lattice. This results in an optimally bulk-truncated surface, meaning the atomic locations do not change upon cleavage. In fact, however, only a few cleavage planes produce stable surface structures, and atomic locations on the surface can differ significantly from those in the bulk.

Figure below depicts the practically most critical cleavage planes and oxide surface orientations. For a cubic lattice, these are the planes (100), (110), and (111), whereas for a hexagonal lattice, these are the planes (0001), (10-10), and (11-20). The surface energy, which is defined as the effort required to break a bulk crystal into two equivalent portions, is the most critical quantity that affects the stability of a certain surface orientation. The surface energy can be thought of as the number of bonds that must be broken per surface atom, or as the number of missing neighbours in the initial coordination sphere in an ionic image. Consider a crystal cut along the (L00), (110), and (111) orientations with a rock salt structure. With respect to the ideal bulk coordination, each surface ion misses just one ion when cut along (100), however for (110) and (111), the number of missing neighbours grows to two and three, respectively. As a result, for oxides with a rock salt structure, the (100) plane is the most stable surface orientation.
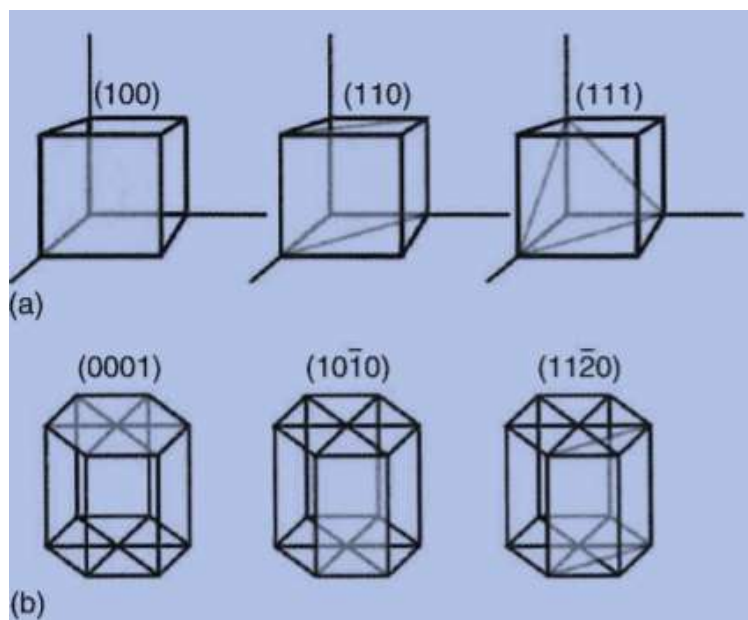
Figure 1: Low-Miller-index planes in a (a) cubic and (b) hexagonal lattice:

Because a cut perpendicular to the (100) crystal direction always results in the formation of two equivalent rock salt (100) surfaces with the same surface structure and number of ions, forming a surface by separating a crystal with rock salt structure is simple. However, for oxide structures with a more complicated stacking sequence, the issue gets more challenging. Figure 2b depicts three methods for separating a rutile-structured crystal to form a (110) surface (dotted lines). In rutile, the stacking sequence in the (110) direction is -o-2Meo-o-o-2Meo-. As a result, splitting the crystal to obtain a -o-2Meo, -o-2Meo-o, or -o-2Meo-o-o terminated surface is a possibility. Only the cut that provides the -O-2MeO-O ending gives two equivalent and stoichiometric surfaces from those three alternatives.
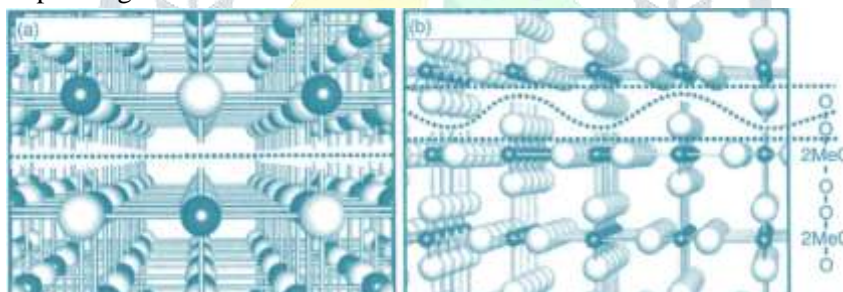

Figure 2: (a) Cut perpendicular to the (100) direction of a crystal with rock salt structure. (b) Different possibilities (dotted lines) for cutting a crystal with rutile structure perpendicular to the (l0'l)directron.

Figure 3 is a representation of the most common ideally bulk-truncated surface structures of oxides. Here, we consider the structure of the surface as being an ideal cut through a bulk crystal plane with the surface ions remaining in positions that they would otherwise have in the bulk. However, in reality, the atomic positions of the outermost surface layers are, due to the surface boundary, often subject to considerable displacement. We will discuss processes that lead to such displacements as well as concepts of surface stability in the proceeding paragraphs. Additionally, any surface plane is never a perfect infinitely extended plane but rather consists of terraces that are separated by monoatomic steps.
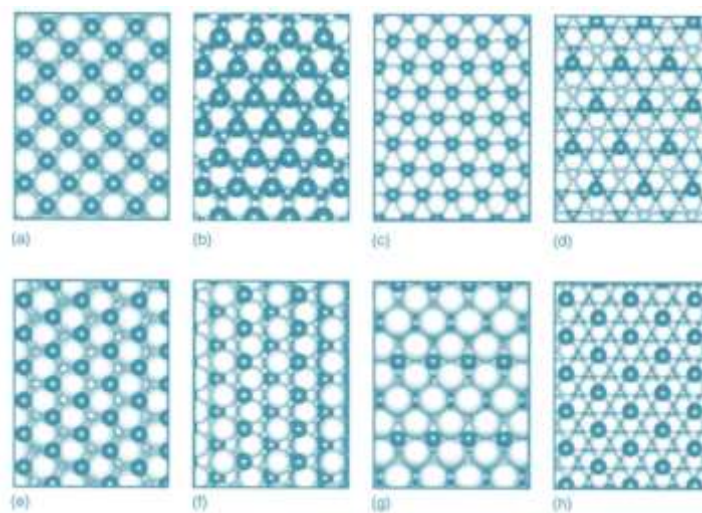
Figure 3: bulk-truncated surface structures of oxides

On the terraces and on steps, a number of defects can exist, the most important ones are vacancies, as shown in Figure below
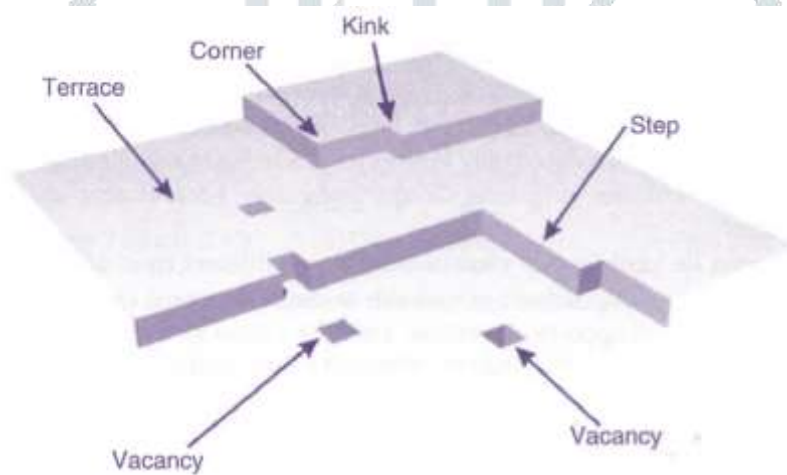

Figure 4: Model of a surface containing steps and point defects.

III. PROPERTIES OF OXIDES

Oxides are a wide-ranging group of chemicals with features that span practically every field of material science and physics. Superconductors and insulators are both possible for oxides. For one system, the bonding qualities may be described as covalent, whereas for the other, they can be defined as strongly ionic. Oxides are used in a variety of technological domains, including paint pigments, nonlinear optics, sensors, and catalysis. In certain circumstances, bulk qualities are critical, as they are frequently in nonlinear optics; in others, such as catalysis, surface features are critical. The thermodynamics, structure - and its nonstoichiometric characteristics, which are particularly significant for oxides - spectroscopy, and transport and mechanical properties of simple binary oxides are all quite well understood, and there are great reviews and books available. Even more intricate oxides, such as ternary and quaternary oxides, are being studied in depth, partially because of their relevance in high-T. superconductivity.
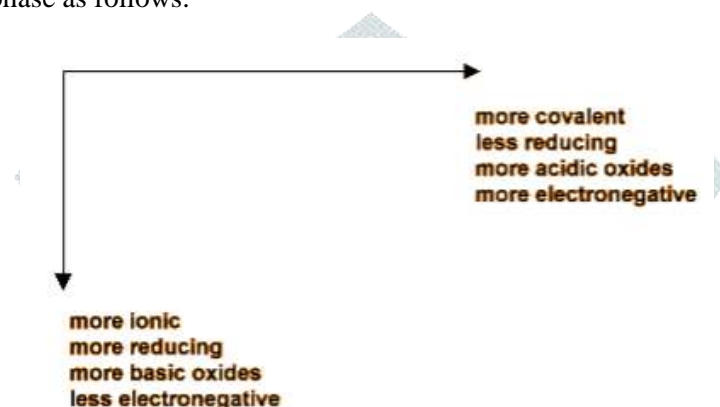
While the bulk characteristics of simple binary oxides are well recognised, the surfaces of oxides, even the simplest ones, remain poorly understood. Researchers have just lately begun to examine the surface science of oxides, compared to the 3Oyears of surface science that have passed. The Surface Science of Oxides, by V. E. Henrich and P. A. Cox, is a highly valuable book that represents the first milestone in this work. Several reviews have emerged since the publication of this book, covering the field up to the current day. It is well established that zeolites and mesoporous materials are two families of technologically significant oxides with exterior and interior surfaces.

The main properties of these oxides linked to applications, such as I stabilised zirconia's heat and

ionic conductivity, (ii) alumina's poor electronic conductivity, and (iii) titania sub-oxides' strong electronic conductivity, are briefly detailed. The most major ores utilised to make these oxides, including I zircon for zirconia, (ii) various ores for rare earth oxides, (iii) bauxite for alumina, and (iv) rutile for titania, are briefly explained, as well as their availability and global use.

IV. TRENDS IN ACID-BASE BEHAVIOR OF OXIDES

As one moves from left to right in an era of the periodic table, the oxides of the elements in that period get increasingly acidic. The behaviour of oxides, for example, alters in the third phase as follows:

more covalent
less reducing
more acidic oxides
more electronegative

more ionic
more reducing
more basic oxides
less electronegative

Aluminum oxide is amphoteric, meaning it has both acid and basic characteristics. As a result, Al_2O_3 denotes the point at which a basic oxide changes to an acidic oxide. It's vital to keep in mind that the trend only applies to oxides in their most oxidised forms. Because the trend does not follow if all oxidation states are represented, each element must be in its maximum potential oxidation state. Notice how each period's amphoteric oxides (shown in blue) represent the transition from basic to acidic oxides.

V. CONCLUSION

Oxides are a crucial component of technical ceramics. The qualities of oxides are linked to their uses. The main features of these oxides related to applications, such as stabilised zirconia's heat and ionic conductivity, and the electronic conductivity of alumina and titania, are briefly outlined. The most major ores utilised to make these oxides, namely I zircon for zirconia, (ii) various ores for rare earth oxides (REO), (iii) bauxite for alumina, and (iv) rutile for titania, are then briefly detailed, as well as their availability and global use. Finally, the pricing of ores and finished oxides, as well as their evolution, are shown and tied to geographic and strategic concerns of exporting nations.

We can better comprehend the acid-base characteristics of oxides if we look at a certain time period. Examining the physical features of oxides may also be beneficial, although it is not required. Metal oxides on the periodic table's left side form basic solutions in water (e.g. Na_2O and MgO). Acidic solutions are produced by nonmetal oxides on the right side of the periodic table (e.g. Cl_2O, SO_2, P_4O_{10}). Within acid-base behaviour, there is a trend: basic oxides are found on the left side of the period, whereas acidic oxides are found on the right. This tendency, however, raises the question of when and where the change will occur. The graph below demonstrates how the oxides become more acidic as we travel from left to right, and more basic as we move from top to bottom.

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