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Multiplicative Reverse Product Connectivity and Multiplicative Reverse Sum Connectivity of Silicate Network

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Abstract

The connectivity indices are helpful to estimate the chemical characteristics of the compounds in chemical graph theory. This report introduces the multiplicative reverse product connectivity index and the multiplicative sum connectivity index of the silicate network. Further, there 2D and 3D graphical representations are plotted.

Keywords: Multiplicative reverse product connectivity index, multiplicative reverse sum connectivity index, silicate network, chemical graph, topological indices

INTRODUCTION

Assume that the basic graph $G = (V, E)$ has the vertex set $V = V(G)$ and the edge set $E = E(G)$. The number of edges that are connected to a vertex, indicated by the symbol $d_G\ (v_i)$, determines its degree. Let $\Delta(G)$ represent the highest vertex degree among a graph's vertices. The reverse vertex degree of the vertex v_i is defined as $c_{v_i} = \Delta(G) - d_G(v_i) + 1$ in [1]. A molecular graph, also known as a chemical graph, is a straightforward graph whose vertices and edges stand in for individual atoms and chemical bonds in chemical graph theory. The graph's topological index is a single integer that can be used to characterize some of its characteristics [2, 3, 4]. Numerous topological indices have been taken into account and used in theoretical chemistry, particularly in QSPR/QSAR research. The multiplicative product connectivity index ($\chi^{\Pi}(G)$) and multiplicative sum connectivity index ($\chi\Pi(G)$) of a molecular graph were described in [5] as follows:

$$\chi^{\Pi}(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{d_G(u)d_G(v)}} \quad \text{and} \quad \chi\Pi(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{d_G(u)+d_G(v)}}$$

New topological indexes have recently been discovered using reverse vertex degree [1, 5, 6, 7, 8, 9]. We define the reverse multiplicative product and reverse sum connectivity index as follows in accordance with applications of the multiplicative product and sum connectivity index:

$$C\chi^{\Pi}(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u . c_v}}\,, \quad \text{and} \quad C\chi\Pi(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u + c_v}} \text{ respectively.}$$

For the Rhombus silicate network, $Si_2C_3I[r,s]$, and $Si_2C_3II[r,s]$, we will compute the reverse multiplicative product and the reverse sum connectivity index in the sections that follow.

MATERIALS AND METHODS

Rhombus Silicates Network

Place silicate ions on each of the vertices of the n-dimensional honeycomb network $HC(n)$. Now, divide each of its edges once, and then add oxygen ions to the newly created vertices. $HC(n)$ 2-degree silicon ions are used to set up 6n new pendant edges, and oxygen ions are inserted at the pendent vertices. The resulting network, known as the silicate network $SL(n)$, is formed when each silicon ion joins the three nearby oxygen ions to form a tetrahedron.

Silicon Carbide Networks

A scientist from the United States discovers silicon carbide in 1891. Today, silica and carbon can be used to artificially create silicon carbide [6, 10]. Up until 1929, silicon carbide was thought to be the world's toughest substance. Because of its Mohs hardness value of 9, it is comparable to a diamond. For $Si_2C_3I[r,s]$ and $Si_2C_3II[r,s]$, where r is the number of connected unit cells in the row and s is the number of connected unit cells in the column, we compute multiplicative reverse sum and product connectivity index.

RESULTS AND DISCUSSION

Results for Rhombus Silicate Networks

Silicate, which is created by fusing metal oxides or metal carbonates withstand, is by far the most fascinating class of minerals [11]. The Rhombus silicate network, also known as $RHSL_n$, is taken into consideration in this section.

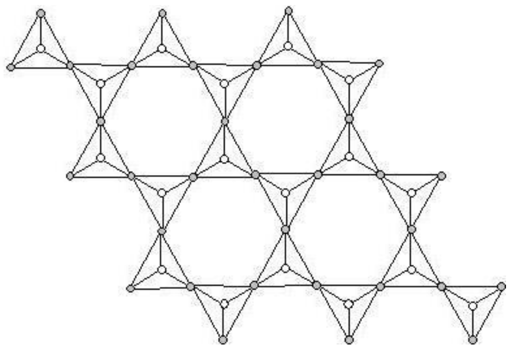

Figure 1 Rhombus silicate network($RHSL_n$).

Theorem 1: Let G be the Rhombus Silicate network ($RHSL_n$) and its multiplicative reverse product connectivity index is given by,

$$C\chi^{\Pi}(G) = \left(\frac{1}{4}\right)^{3n^2+6n}$$

Proof: There are $12n^2$ edges and $5n^2 + 2n$ vertices in the $RHSL_n$ network. $RHSL'_n s$ vertices are obviously either of degrees 3 or 6. Then $\Delta(G) = 6$, the highest degree of a vertex. By using an algebraic approach, there are three different kinds of edge partitions in $RHSL_n$:

$E_{\{3,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=3=d_G(v)}\}$,
$E_{\{3,6\}}(G) = \{e = uv \in E(G)|_{d_G(u)=3,\, d_G(v)=6}\}$ and
$E_{\{6,6\}}(G) = \{e = uv \in E(G)|_{d_G(u)=6=d_G(v)}\}$ such that,
$|E_{\{3,3\}}(G)| = 4n + 2$,
$|E_{\{3,6\}}(G)| = 6n^2 + 4n - 4$ and
$|E_{\{6,6\}}(G)| = 6n^2 - 8n + 2$.

We have reverse vertex degree, $c_v = \Delta(G) - d_G(v) + 1 = 7 - d_G(v)$

Now we see reverse edge partitions as follows:

$CE_{\{4,4\}}(G) = \{e = uv \in E(G)|_{c_u=4=c_v}\}$,
$CE_{\{4,1\}}(G) = \{e = uv \in E(G)|_{c_u=4,c_v=1}\}$ and
$CE_{\{1,1\}}(G) = \{e = uv \in E(G)|_{c_u=1=c_v}\}$.

Table 1 Reverse edge partition of $RHSL_n$.

$c_u, c_v / uv \in E(G)$	**Number of reverse edges**
(4,4)	$4n + 2$
(4,1)	$6n^2 + 4n - 4$
(1,1)	$6n^2 - 8n + 2$

We have,

$$C\chi^{\Pi}(G) = \prod_{uv \in E(E)} \frac{1}{\sqrt{c_u . c_v}}$$

By using Table 1, we have

$$\begin{aligned} C\chi^{\Pi}(G) &= \left(\frac{1}{\sqrt{4 \cdot 4}}\right)^{4n+2} \times \left(\frac{1}{\sqrt{4 \cdot 1}}\right)^{6n^2+4n-4} \times \left(\frac{1}{\sqrt{1 \cdot 1}}\right)^{6n^2-8n+2} \\ &= \left(\frac{1}{4}\right)^{4n+2} \times \left(\frac{1}{2}\right)^{6n^2+4n-4} \times \left(\frac{1}{1}\right)^{6n^2-8n+2} \\ &= \left(\frac{1}{4}\right)^{4n+2} \times \left(\frac{1}{4}\right)^{3n^2+2n-2} \\ &= \left(\frac{1}{4}\right)^{3n^2+6n} \end{aligned}$$

Theorem 2: Let G be the Rhombus Silicate network ($RHSL_n$) and its multiplicative reverse sum connectivity index is given by,

$$C\chi\Pi(RHSL_n) = \left(\frac{1}{\sqrt{8}}\right)^{4n+2} \times \left(\frac{1}{\sqrt{5}}\right)^{6n^2+4n-4} \times \left(\frac{1}{\sqrt{2}}\right)^{6n^2-8n+2}$$

Proof: We have,

$$C\chi\Pi(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u + c_v}}$$

By using Table 1, we have:

$$\begin{aligned} C\chi\Pi(G) &= \left(\frac{1}{\sqrt{4+4}}\right)^{4n+2} \times \left(\frac{1}{\sqrt{4+1}}\right)^{6n^2+4n-4} \times \left(\frac{1}{\sqrt{1+1}}\right)^{6n^2-8n+2} \\ &= \left(\frac{1}{\sqrt{8}}\right)^{4n+2} \times \left(\frac{1}{\sqrt{5}}\right)^{6n^2+4n-4} \times \left(\frac{1}{\sqrt{2}}\right)^{6n^2-8n+2} \end{aligned}$$

Results for Silicon Carbide $Si_2C_3I[r,s]$

An American scientist made the discovery of silicon carbide in 1891. Silica and carbon can be used artificially to create it [4]. For $Si_2C_3I[r,s]$, where r is the number of connected unit cells in the row and s is the number of connected unit cells in the column, we will compute the multiplicative reverse sum and product connectivity index.

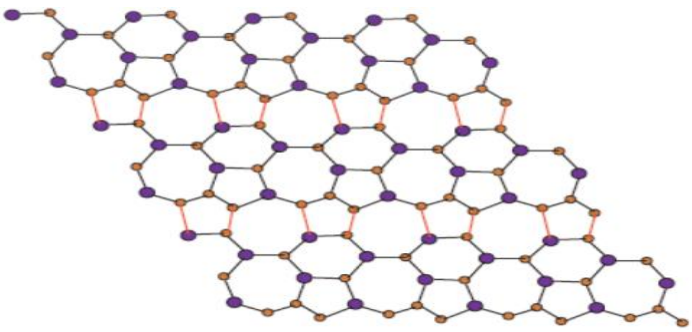

Figure 2 $Si_2C_3I[r,s]$for $r = 4$, $s = 2$.

Theorem 3: Let G be the graph of $Si_2C_3I[r,s]$ and its multiplicative reverse product connectivity index is given by,

$$C\chi^{\Pi}(G) = \left(\frac{1}{\sqrt{6}}\right) \times \left(\frac{1}{\sqrt{3}}\right) \times \left(\frac{1}{2}\right)^{r+2s} \times \left(\frac{1}{\sqrt{2}}\right)^{6r+8s-9}$$

Proof: In $Si_2C_3, I[r,s]$ have $15rs - 2r - 3s$ edges and $10rs$ vertices. Following are the five edge partitions found in $Si_2C_3I[r,s]$:

$E_{\{1,2\}}(G) = \{e = uv \in E(G)|_{d_G(u)=1, d_G(v)=2}\}$,
$E_{\{1,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=1,\ d_G(v)=3}\}$,
$E_{\{2,2\}}(G) = \{e = uv \in E(G)|_{d_G(u)=2,\ d_G(v)=2}\}$,
$E_{\{2,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=2,\ d_G(v)=3}\}$ and
$E_{\{3,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=3,\ d_G(v)=3}\}$, such that
$|E_{\{1,2\}}(G)| = 1$,
$|E_{\{1,3\}}(G)| = 1$,
$|E_{\{2,2\}}(G)| = r + 2s$,

$|E_{\{2,3\}}(G| = 6r + 8s - 9,$ and
$|E_{\{3,3\}}(G| = 15rs - 9r - 13s + 7.$

As, the maximum degree in $Si_2C_3I[r,s]$ are 3 so, $c_v = \Delta(G) - d_G(v) + 1 = 4 - d_G(v)$.The reverse edge partition is as follows:

$CE_{\{3,2\}}(G) = \{e = uv \in (G)|_{c_u=3,c_v=2}\},$
$CE_{\{3,1\}}(G) = \{e = uv \in E(G)|_{c_u=3,c_v=1}\},$
$CE_{\{2,2\}}(G) = \{e = uv \in E(G)|_{c_u=2,c_v=2}\},$
$CE_{\{2,1\}}(G) = \{e = uv \in E(G)|_{c_u=2,c_v=1}\}$, and
$CE_{\{1,1\}}(G) = \{e = uv \in E(G)|_{c_u=1,c_v=1}\}.$

Table 2 Reverse edge partition of $Si_2C_3I[r,s]$.

$c_u, c_v/uv \in E(G)$	**Number of reverse edges**
(3,2)	1
(3,1)	1
(2,2)	$r + 2s$
(2,1)	$6r + 2s - 9$
(1,1)	$15rs - 13r - 13s + 7$

We have,

$$C\chi^{\Pi}(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u . c_v}}$$

By using Table 2, we have

$$\begin{aligned} C\chi^{\Pi}(G) &= \left(\frac{1}{\sqrt{3\cdot 2}}\right)^{1} \times \left(\frac{1}{\sqrt{3\cdot 1}}\right)^{1} \times \left(\frac{1}{\sqrt{2\cdot 2}}\right)^{r+2s} \times \left(\frac{1}{\sqrt{2\cdot 1}}\right)^{6r+8s-9} \times \left(\frac{1}{\sqrt{1\cdot 1}}\right)^{15rs-9r-13s+7} \\ &= \left(\frac{1}{\sqrt{6}}\right)^{1} \times \left(\frac{1}{\sqrt{3}}\right)^{1} \times \left(\frac{1}{\sqrt{4}}\right)^{r+2s} \times \left(\frac{1}{\sqrt{2}}\right)^{6r+8s-9} \\ &= \left(\frac{1}{\sqrt{6}}\right) \times \left(\frac{1}{\sqrt{3}}\right) \times \left(\frac{1}{2}\right)^{r+2s} \times \left(\frac{1}{\sqrt{2}}\right)^{6r+8s-9} \end{aligned}$$

Theorem 4: The Let G be the graph of $Si_2C_3I[r,s]$ and its multiplicative reverse sum connectivity index is given by,

$$C\chi\Pi(G) = \left(\frac{1}{\sqrt{5}}\right) \times \left(\frac{1}{2}\right)^{r+2s} \times \left(\frac{1}{\sqrt{3}}\right)^{6r+8s-9} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-9r-13s+7}$$

Proof:
We have,

$$C\chi\Pi(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u + c_v}}$$

By using Table 2, we have:

$$\begin{aligned} C\chi\Pi(G) &= \left(\frac{1}{\sqrt{3+2}}\right)^{1} \times \left(\frac{1}{\sqrt{3+1}}\right)^{1} \times \left(\frac{1}{\sqrt{2+2}}\right)^{r+2s} \times \left(\frac{1}{\sqrt{2+1}}\right)^{6r+8s-9} \times \left(\frac{1}{\sqrt{1+1}}\right)^{15rs-9r-13s+7} \\ &= \left(\frac{1}{\sqrt{5}}\right) \times \left(\frac{1}{2}\right) \times \left(\frac{1}{2}\right)^{r+2s} \times \left(\frac{1}{\sqrt{3}}\right)^{6r+8s-9} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-9r-13s+7} \\ &= \left(\frac{1}{\sqrt{5}}\right) \times \left(\frac{1}{2}\right)^{r+2s+1} \times \left(\frac{1}{\sqrt{3}}\right)^{6r+8s-9} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-9r-13s+7} \end{aligned}$$

Results for Silicon Carbide $Si_2C_3II[r,s]$

For silicon carbide $Si_2C_3II[r,s]$, we will compute the multiplicative reverse sum and product connectivity index in this section.

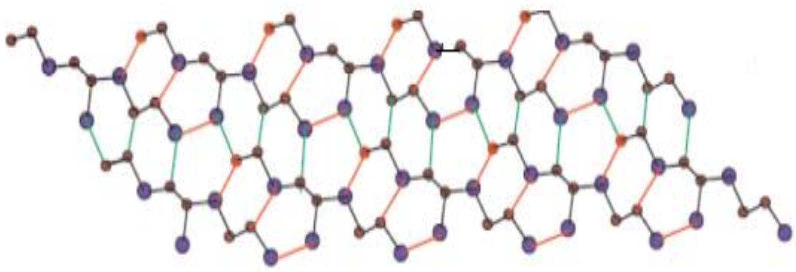

Figure 3 $Si_2C_3II[r,s]$for $r = 5$, $s = 2$.

Theorem 5 Let G be the graph of $Si_2C_3II[r,s]$ and its multiplicative reverse product connectivity index is given by,

$$C\chi^{\Pi}(G) = \left(\frac{1}{6}\right) \times \left(\frac{1}{\sqrt{3}}\right) \times \left(\frac{1}{2}\right)^{10r+10s-14}$$

Proof: In $Si_2C_3II[r,s]$ have$10rs$ vertices and $15rs - 2r - 3s$ edges. There are five edge partitions in $Si_2C_3I[r,s]$ and are as follows:

$E_{\{1,2\}}(G) = \{e = uv \in E(G)|_{d_G(u)=1,\ d_G(v)=2}\}$,
$E_{\{1,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=1,\ d_G(v)=3}\}$,
$E_{\{2,2\}}(G) = \{e = uv \in E(G)|_{d_G(u)=2,\ d_G(v)=2}\}$,
$E_{\{2,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=2,\ d_G(v)=3}\}$ and
$E_{\{3,3\}}(G) = \{e = uv \in E(G)|_{d_G(u)=3,\ d_G(v)=3}\}$,such that
$|E_{\{1,2\}}(G)| = 1$,
$|E_{\{1,3\}}(G)| = 1$,
$|E_{\{2,2\}}(G)| = r + 2s$,
$|E_{\{2,3\}}(G)| = 6r + 8s - 9$, and
$|E_{\{3,3\}}(G)| = 15rs - 9r - 13s + 7$.

As, the maximum degree in $Si_2C_3II[r,s]$ is 3. So, $c_v = \Delta(G) - d_G(v) + 1 = 4 - d_G(v)$.
The reverse edge partition are as follows:

$CE_{\{3,2\}}(G) = \{e = uv \in (G)|_{c_u=3,c_v=2}\}$,
$CE_{\{3,1\}}(G) = \{e = uv \in E(G)|_{c_u=3,c_v=1}\}$,
$CE_{\{2,2\}}(G) = \{e = uv \in E(G)|_{c_u=2,c_v=2}\}$,
$CE_{\{2,1\}}(G) = \{e = uv \in E(G)|_{c_u=2,c_v=1}\}$, and
$CE_{\{1,1\}}(G) = \{e = uv \in E(G)|_{c_u=1,c_v=1}\}$.

Table 3 Reverse edge partition of $Si_2C_3II[r,s]$.

$c_u, c_v/uv \in E(G)$	**Number of reverse edges**
(3,2)	2
(3,1)	1
(2,2)	$2r + 2s$
(2,1)	$8r + 8s - 14$
(1,1)	$15rs - 13r - 13s + 14$

We have,

$$C\chi^{\Pi}(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u . c_v}}$$

By using Table 3 we have,

$$\begin{aligned} C\chi^{\Pi}(G) &= \left(\frac{1}{\sqrt{3\cdot 2}}\right)^2 \times \left(\frac{1}{\sqrt{3\cdot 1}}\right)^1 \times \left(\frac{1}{\sqrt{2\cdot 2}}\right)^{2r+2s} \times \left(\frac{1}{\sqrt{2\cdot 1}}\right)^{8r+8s-14} \times \left(\frac{1}{\sqrt{1\cdot 1}}\right)^{15rs-13r-13s+14} \\ &= \left(\frac{1}{\sqrt{6}}\right)^2 \times \left(\frac{1}{\sqrt{3}}\right)^1 \times \left(\frac{1}{\sqrt{4}}\right)^{2r+2s} \times \left(\frac{1}{\sqrt{2}}\right)^{8r+8s-14} \\ &= \left(\frac{1}{6}\right) \times \left(\frac{1}{\sqrt{3}}\right) \times \left(\frac{1}{2}\right)^{10r+10s-14} \end{aligned}$$

Theorem 6: Let G be the graph of $Si_2C_3II[r,s]$ and its multiplicative reverse sum connectivity index is given by,

$$C\chi\Pi(G) = \left(\frac{1}{10}\right) \times \left(\frac{1}{2}\right)^{2r+2s} \times \left(\frac{1}{3}\right)^{4r+4s-7} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-13r-13s+14}$$

Proof: We have,

$$C\chi\Pi(G) = \prod_{uv\in E(E)} \frac{1}{\sqrt{c_u + c_v}}$$

By using Table 3, we have

$$
\begin{aligned}
C\chi^{\Pi}(G) &= \left(\frac{1}{\sqrt{3+2}}\right)^{2} \times \left(\frac{1}{\sqrt{3+1}}\right)^{1} \times \left(\frac{1}{\sqrt{2+2}}\right)^{2r+2s} \times \left(\frac{1}{\sqrt{2+1}}\right)^{8r+8s-14} \times \left(\frac{1}{\sqrt{1+1}}\right)^{15rs-13r-13s+14} \\
&= \left(\frac{1}{\sqrt{5}}\right)^{2} \times \left(\frac{1}{\sqrt{4}}\right)^{1} \times \left(\frac{1}{\sqrt{4}}\right)^{2r+2s} \times \left(\frac{1}{\sqrt{3}}\right)^{8r+8s-14} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-13r-13s+14} \\
&= \left(\frac{1}{5}\right) \times \left(\frac{1}{2}\right) \times \left(\frac{1}{2}\right)^{2r+2s} \times \left(\frac{1}{3}\right)^{4r+4s-7} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-13r-13s+14} \\
&= \left(\frac{1}{10}\right) \times \left(\frac{1}{2}\right)^{2r+2s} \times \left(\frac{1}{3}\right)^{4r+4s-7} \times \left(\frac{1}{\sqrt{2}}\right)^{15rs-13r-13s+14}
\end{aligned}
$$

CONCLUSION

The connectivity indices are helpful in computing the chemical properties of molecules in chemical graph theory. These indices are also helpful for researching the anti-inflammatory properties of specific chemical compounds. The multiplicative reverse product connectivity and multiplicative reverse sum connectivity of the silicate network can be observed in this research. Figures 4 and 5 (for $n = 1,2,3,4,5$) display the 2D graphical comparisons of the multiplicative reverse product and sum connectivity indices. Figures 6 to 9 (for $1 \leq r, s \leq 20$) display 3D graphical comparisons between the reverse product and sum connectivity indexes of $Si_2\, C_3\, I[r,s]$ and $Si_2\, C_3\, II[r,s]$. It is evident from these figures that for n bigger than 2, the values of the multiplicative reverse product and sum connectivity indices are almost zero. Video provides a powerful way to help you prove your point.

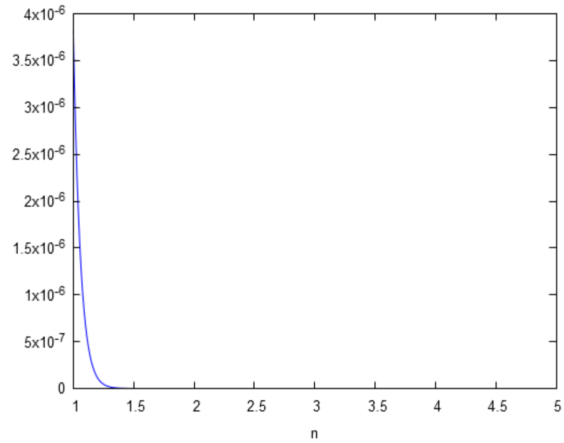

Figure 4 The graphical representation of multiplicative reverse product connectivity index of Rhombus silicate network $RHSL_n$ for $n = 1,2,3,4,5$.

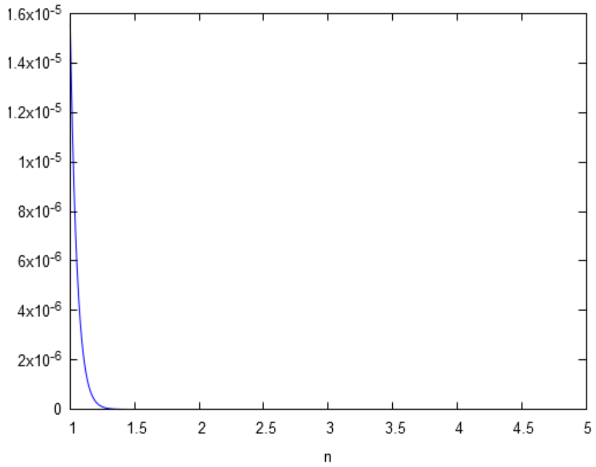

Figure 5 The graphical representation of multiplicative reverse sum connectivity index of Rhombus silicate network $RHSL_n$ for $n = 1,2,3,4,5$.

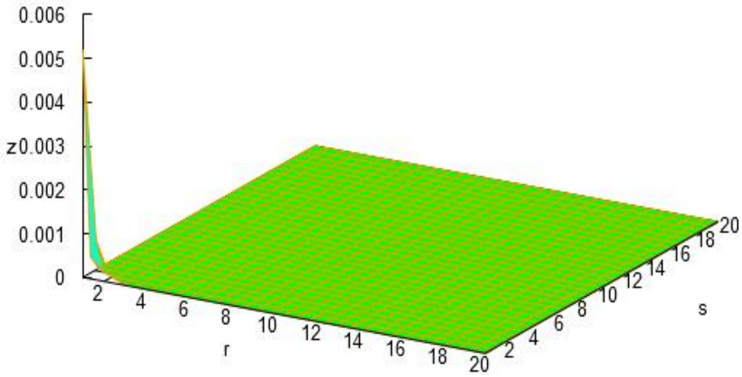

Figure 6 The graphical representation of multiplicative reverse product connectivity index of $Si_2C_3I[r,s]$ for $1 \leq r,s \leq 20$.

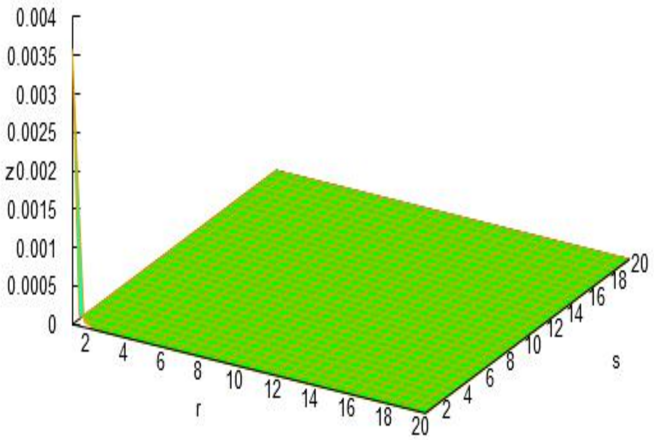

Figure 7 The graphical representation of multiplicative reverse sum connectivity index of $Si_2C_3I[r,s]$ for $1 \leq r,s \leq 20$.

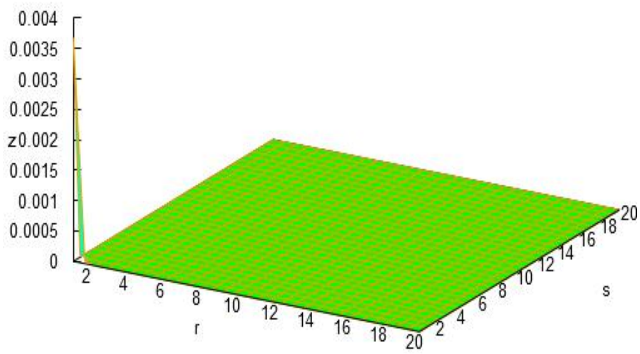

Figure 8 The graphical representation of multiplicative reverse product connectivity index of $Si_2C_3II[r,s]$ for $1 \leq r,s \leq 20$.

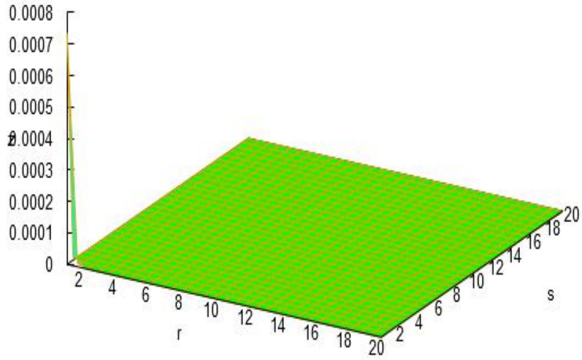

Figure 9 The graphical representation of multiplicative reverse sum connectivity index of $Si_2C_3II[r,s]$ for $1 \leq r,s \leq 20$.

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