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Research Article

MULTIPLICATIVE CONNECTIVITY ve-DEGREE INDICES OF DOMINATING OXIDE AND REGULAR TRIANGULATE OXIDE NETWORKS

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A B S T R A C T

In Chemical Graph Theory, connectivity indices have been found useful in practical application. Recently, the ve-degree concept is defined in Graph Theory. In this paper, we introduce the multiplicative product connectivity ve-degree index, multiplicative sum connectivity ve-degree index, multiplicative atom bond connectivity ve-degree index and multiplicative geometric-arithmetic ve-degree index of a molecular graph. Furthermore we compute these multiplicative connectivity ve-degree indices of chemically interesting networks like dominating oxide and regular triangulate oxide networks.

INTRODUCTION

A molecular graph is a simple graph related to the structure of a chemical compound. Each vertex of this graph represents an atom of the molecule and its edges to the bond between atoms. A topological index is numerical parameter mathematically derived from the graph structure. Chemical Graph Theory is a branch of Mathematical Chemistry which has an important effect on the development of chemical sciences. There are many topological indices that have some applications in Chemistry, see [1].

Let G be a finite, simple connected graph with vertex set $V(G)$ and edge set $E(G)$. The degree $d_G(v)$ of a vertex v is the number of vertices adjacent to v. Let S_v denote the sum degrees of all vertices adjacent to a vertex v. We call S_v as sum degree. The set of all vertices which adjacent to v is called the open neighborhood of v and denoted by $N(v)$. The set $N(v) \cup \{v\}$ is called the closed neighborhood of v and denoted by $N[v]$.

In [2], Chellali et al. defined the ve-degree concept in Graph Theory as follows:

The ve-degree $d_{ve}(v)$ of a vertex v in a connected graph G is the number of different edges that incident to any vertex from the closed neighborhood of v.

The following multiplicative connectivity indices of a graph were introduced by Kulli in [3]. They are defined as follows:

The multiplicative product connectivity index of a graph G is defined as

$$PII(G)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_G(u)d_G(v)}}.$$

The multiplicative sum connectivity index of a graph G is defined as

$$SII(G)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_G(u)+d_G(v)}}.$$

The multiplicative atom bond connectivity index of a graph G is defined as

$$ABCII(G)=\prod_{uv\in E(G)}\sqrt{\frac{d_G(u)+d_G(v)-2}{d_G(u)d_G(v)}}.$$

The multiplicative geometric-arithmetic index of a graph G is defined as

$$GAII(G)=\prod_{uv\in E(G)}\frac{2\sqrt{d_G(u)d_G(v)}}{d_G(u)+d_G(v)}.$$

Motivated by the definitions of the multiplicative connectivity indices and their applications, we introduce the multiplicative product connectivity ve-degree index, multiplicative sum connectivity ve-degree index, multiplicative atom bond connectivity ve-degree index and multiplicative geometric-arithmetic ve-degree index of a graph as follows:

The multiplicative product connectivity ve-degree index of a graph G is defined as

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$$P_{ve}II(G)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)d_{ve}(v)}}. \quad (1)$$

The multiplicative sum connectivity ve-degree index of a graph G is defined as

$$S_{ve}II(G)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)+d_{ve}(v)}}. \quad (2)$$

The multiplicative atom bond connectivity ve-degree index of a graph G is defined as

$$ABC_{ve}II(G)=\prod_{uv\in E(G)}\sqrt{\frac{d_{ve}(u)+d_{ve}(v)-2}{d_{ve}(u)d_{ve}(v)}}. \quad (3)$$

The multiplicative geometric-arithmetic ve-degree index of a graph G is defined as

$$GA_{ve}II(G)=\prod_{uv\in E(G)}\frac{2\sqrt{d_{ve}(u)d_{ve}(v)}}{d_{ve}(u)+d_{ve}(v)}. \quad (4)$$

Recently, some ve-degree topological indices were studied, for example, in [4, 5, 6, 7, 8].

We consider the families of dominating oxide networks and regular triangulate oxide networks [9, 10]. In this paper, we compute the multiplicative connectivity ve-degree indices for dominating oxide networks (DOX) and regular triangulate oxide networks (RTOX).

Results For Dominating Oxide Networks DOX(n)

The molecular structure of a dominating oxide network is presented in Figure 1. The family of oxide networks is symbolized by $DOX(n)$.

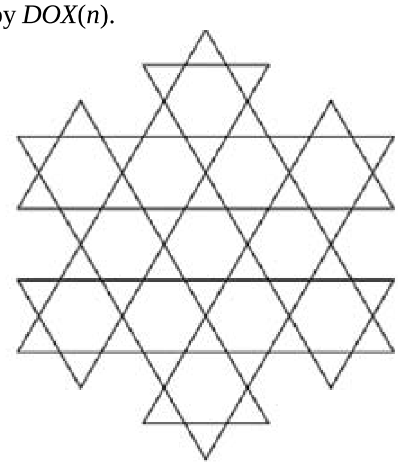

Figure 1 The structure of a dominating oxide network

In [9], Ediz obtained the partition of the edges with respect to their sum degree of end vertices of dominating oxide networks in Table 1.

Table 1

$(S_u, S_v)\backslash uv \in E(G)$	(8, 12)	(8, 14)	(12, 12)	(12, 14)	(14, 16)	(16, 16)
Number of edges	$12n$	$12n-12$	6	$12n-12$	$24n-24$	$54n^2-114n+60$

Also he has given the ve-degree partition of the end vertices of edges for dominating oxide networks in Table 2.

Table 2

$(d_{ve}(u), d_{ve}(v))\backslash uv \in E(G)$	(7, 10)	(7, 12)	(10, 10)	(10, 12)	(12, 14)	(14, 14)
Number of edges	$12n$	$12n-12$	6	$12n-12$	$24n-24$	$54n^2-114n+60$

We now compute multiplicative connectivity ve-degree indices of $DOX(n)$.

Theorem 1: The multiplicative product connectivity ve-degree index of a dominating oxide network $DOX(n)$ is

$$P_{ve}II(DOX(n))=\left(\frac{1}{70}\right)^{6n}\times\left(\frac{1}{84}\right)^{6n-6}\times\left(\frac{1}{10}\right)^{6}\times\left(\frac{1}{120}\right)^{6n-6}\times\left(\frac{1}{168}\right)^{12n-12}\times\left(\frac{1}{14}\right)^{54n^2-114n+60}.$$

Proof: Let G be the molecular graph of a dominating oxide network $DOX(n)$. By using equation (1) and Table 2, we deduce

$$P_{ve}II(DOX(n))=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)d_{ve}(v)}}$$

$$=\left(\frac{1}{\sqrt{7\times 10}}\right)^{12n}\times\left(\frac{1}{\sqrt{7\times 12}}\right)^{12n-12}\times\left(\frac{1}{\sqrt{10\times 10}}\right)^{6}\times\left(\frac{1}{\sqrt{10\times 12}}\right)^{12n-12}$$

$$\times\left(\frac{1}{\sqrt{12\times 14}}\right)^{24n-24}\times\left(\frac{1}{\sqrt{14\times 14}}\right)^{54n^2-114n+60}$$

$$=\left(\frac{1}{70}\right)^{6n}\times\left(\frac{1}{84}\right)^{6n-6}\times\left(\frac{1}{10}\right)^{6}\times\left(\frac{1}{120}\right)^{6n-6}\times\left(\frac{1}{168}\right)^{12n-12}\times\left(\frac{1}{14}\right)^{54n^2-114n+60}.$$

Theorem 2: The multiplicative sum connectivity ve-degree index of a dominating oxide network $DOX(n)$ is

$$S_{ve}II(DOX(n))=\left(\frac{1}{17}\right)^{6n}\times\left(\frac{1}{19}\right)^{6n-6}\times\left(\frac{1}{20}\right)^{3}\times\left(\frac{1}{22}\right)^{6n-6}\times\left(\frac{1}{26}\right)^{12n-12}\times\left(\frac{1}{28}\right)^{27n^2-57n+30}.$$

Proof: Let G be the molecular graph of a dominating oxide network $DOX(n)$. By using equation (2) and Table 2, we deduce

$$S_{ve}II(DOX(n))=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)+d_{ve}(v)}}$$

$$=\left(\frac{1}{\sqrt{7+10}}\right)^{12n}\times\left(\frac{1}{\sqrt{7+12}}\right)^{12n-12}\times\left(\frac{1}{\sqrt{10+10}}\right)^{6}\times\left(\frac{1}{\sqrt{10+12}}\right)^{12n-12}$$

$$\times\left(\frac{1}{\sqrt{12+14}}\right)^{24n-24}\times\left(\frac{1}{\sqrt{14+14}}\right)^{54n^2-114n+60}$$

$$=\left(\frac{1}{17}\right)^{6n}\times\left(\frac{1}{19}\right)^{6n-6}\times\left(\frac{1}{20}\right)^{3}\times\left(\frac{1}{22}\right)^{6n-6}\times\left(\frac{1}{26}\right)^{12n-12}\times\left(\frac{1}{28}\right)^{27n^2-57n+30}.$$

***Theorem 3*:** The multiplicative atom bond connectivity ve-degree index of a dominating oxide network $DOX(n)$ is

$$ABC_{ve}II(DOX(n))=\left(\frac{3}{14}\right)^{6n}\times\left(\frac{17}{84}\right)^{6n-6}\times\left(\frac{9}{50}\right)^{3}\times\left(\frac{1}{6}\right)^{6n-6}\times\left(\frac{1}{7}\right)^{12n-12}\times\left(\frac{13}{98}\right)^{27n^2-57n+30}.$$

Proof: Let G be the molecular graph of a dominating oxide network $DOX(n)$. By using equation (3) and Table 2, we deduce

$$ABC_{ve}II(DOX(n))=\prod_{uv\in E(G)}\sqrt{\frac{d_{ve}(u)+d_{ve}(v)-2}{d_{ve}(u)d_{ve}(v)}}$$

$$=\left(\sqrt{\frac{7+10-2}{7\times 10}}\right)^{12n}\times\left(\sqrt{\frac{7+12-2}{7\times 12}}\right)^{12n-12}\times\left(\sqrt{\frac{10+10-2}{10\times 10}}\right)^{6}\times\left(\sqrt{\frac{10+12-2}{10\times 12}}\right)^{12n-12}$$

$$\times\left(\sqrt{\frac{12+14-2}{12\times 14}}\right)^{24n-24}\times\left(\sqrt{\frac{14+14-2}{14\times 14}}\right)^{54n^2-114n+60}$$

$$=\left(\frac{3}{14}\right)^{6n}\times\left(\frac{17}{84}\right)^{6n-6}\times\left(\frac{9}{50}\right)^{3}\times\left(\frac{1}{6}\right)^{6n-6}\times\left(\frac{1}{7}\right)^{12n-12}\times\left(\frac{13}{98}\right)^{27n^2-57n+30}.$$

Theorem 4: The multiplicative geometric-arithmetic ve-degree index of a dominating oxide network $DOX(n)$ is

$$GA_{ve}II\left(DOX\left(n\right)\right)=\left(\frac{2\sqrt{70}}{17}\right)^{12n}\times\left(\frac{4\sqrt{21}}{19}\right)^{12n-12}\times\left(\frac{2\sqrt{30}}{11}\right)^{12n-12}\times\left(\frac{2\sqrt{42}}{13}\right)^{24n-24}.$$

Proof: Let G be the molecular graph of a dominating oxide network $DOX(n)$. By using equation (4) and Table 2, we deduce

$$GA_{ve}II\left(DOX\left(n\right)\right)=\prod_{uv\in E(G)}\frac{2\sqrt{d_{ve}(u)d_{ve}(v)}}{d_{ve}(u)+d_{ve}(v)}$$

$$=\left(\frac{2\sqrt{7\times 10}}{7+10}\right)^{12n}\times\left(\frac{2\sqrt{7\times 12}}{7+12}\right)^{12n-12}\times\left(\frac{2\sqrt{10\times 10}}{10+10}\right)^{6}\times\left(\frac{2\sqrt{10\times 12}}{10+12}\right)^{12n-12}$$

$$\times\left(\frac{2\sqrt{12\times 14}}{12+14}\right)^{24n-24}\times\left(\frac{2\sqrt{14\times 14}}{14+14}\right)^{54n^2-114n+60}.$$

$$=\left(\frac{2\sqrt{70}}{17}\right)^{12n}\times\left(\frac{4\sqrt{21}}{19}\right)^{12n-12}\times\left(\frac{2\sqrt{30}}{11}\right)^{12n-12}\times\left(\frac{2\sqrt{42}}{13}\right)^{24n-24}.$$

Results For Regular Triangulate Oxide Networks RTOX(n)

The molecular structure of a regular triangulate oxide network is presented in Figure 2. The family of regular triangulate oxide networks is denoted by $RTOX(n)$, $n\geq 3$.

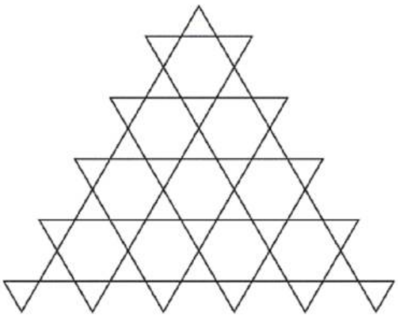

Figure 2 The graph of a regular triangulate oxide network $RTOX(5)$

In [9], Ediz has given the partition of the edges with respect to their sum degree of end vertices of regular triangulate oxide networks in Table 3.

Table 3

(S_u, S_v)	(6,6)	(6,12)	(8,12)	(8,14)	(12,12)	(12,14)	(14,14)	(14,16)	(16, 16)
Number of edges	2	4	4	$6n-8$	1	6	$6n-9$	$6n-12$	$3n^2-12n+12$

Also he has given the ve-degree partition of the end vertices of edges for regular triangulate oxide networks in Table 4.

Table 4

$(d_{ve}(u), d_{ve}(v))$	(5,5)	(5,10)	(7,10)	(7,12)	(10,10)	(10,12)	(12,12)	(12,14)	(14,14)
Number of edges	2	4	4	$6n-8$	1	6	$6n-9$	$6n-12$	$3n^2-12n+12$

We now compute the multiplicative product connectivity ve-degree index of $RTOX(n)$.

Theorem 5: The multiplicative product connectivity ve-degree index of a regular triangulate oxide network $RTOX(n)$ is

$$P_{ve}II\left(RTOX(n)\right)=\left(\frac{1}{5}\right)^{2}\times\left(\frac{1}{50}\right)^{2}\times\left(\frac{1}{70}\right)^{2}\times\left(\frac{1}{10}\right)^{1}\times\left(\frac{1}{120}\right)^{3}\times\left(\frac{1}{84}\right)^{3n-4}$$

$$\times\left(\frac{1}{12}\right)^{6n-9}\times\left(\frac{1}{168}\right)^{3n-6}\times\left(\frac{1}{14}\right)^{3n^2-12n+12}.$$

Proof: Let G be the molecular graph of a regular triangulate oxide network $RTOX(n)$. By using equation (1) and Table 4, we deduce

$$P_{ve}II\left(RTOX\left(n\right)\right)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)d_{ve}(v)}}$$

$$=\left(\frac{1}{\sqrt{5\times 5}}\right)^{2}\times\left(\frac{1}{\sqrt{5\times 10}}\right)^{4}\times\left(\frac{1}{\sqrt{7\times 10}}\right)^{4}\times\left(\frac{1}{\sqrt{7\times 12}}\right)^{6n-8}\times\left(\frac{1}{\sqrt{10\times 10}}\right)^{1}$$

$$\times\left(\frac{1}{\sqrt{10\times 12}}\right)^{6}\times\left(\frac{1}{\sqrt{12\times 12}}\right)^{6n-9}\times\left(\frac{1}{\sqrt{12\times 14}}\right)^{6n-12}\times\left(\frac{1}{\sqrt{14\times 14}}\right)^{3n^2-12n+12}.$$

$$=\left(\frac{1}{5}\right)^{2}\times\left(\frac{1}{50}\right)^{2}\times\left(\frac{1}{70}\right)^{2}\times\left(\frac{1}{10}\right)^{1}\times\left(\frac{1}{120}\right)^{3}\times\left(\frac{1}{84}\right)^{3n-4}$$

$$\times\left(\frac{1}{12}\right)^{6n-9}\times\left(\frac{1}{168}\right)^{3n-6}\times\left(\frac{1}{14}\right)^{3n^2-12n+12}.$$

Theorem 6. The multiplicative sum connectivity ve-degree index of a regular triangulate oxide network $RTOX(n)$ is

$$S_{ve}II\left(RTOX\left(n\right)\right)=\left(\frac{1}{10}\right)^{1}\times\left(\frac{1}{15}\right)^{2}\times\left(\frac{1}{17}\right)^{2}\times\left(\frac{1}{\sqrt{20}}\right)^{1}\times\left(\frac{1}{22}\right)^{3}\times\left(\frac{1}{19}\right)^{3n-4}$$

$$\times\left(\frac{1}{\sqrt{24}}\right)^{6n-9}\times\left(\frac{1}{26}\right)^{3n-6}\times\left(\frac{1}{\sqrt{28}}\right)^{3n^2-12n+12}.$$

Proof: Let G be the molecular graph of a regular triangulate oxide network $TROX(n)$. By using equation (2) and Table 4, we deduce

$$S_{ve}II\left(TROX\left(n\right)\right)=\prod_{uv\in E(G)}\frac{1}{\sqrt{d_{ve}(u)+d_{ve}(v)}}$$

$$=\left(\frac{1}{\sqrt{5+5}}\right)^{2}\times\left(\frac{1}{\sqrt{5+10}}\right)^{4}\times\left(\frac{1}{\sqrt{7+10}}\right)^{4}\times\left(\frac{1}{\sqrt{7+12}}\right)^{6n-8}\times\left(\frac{1}{\sqrt{10+10}}\right)^{1}$$

$$\times\left(\frac{1}{\sqrt{10+12}}\right)^{6}\times\left(\frac{1}{\sqrt{12+12}}\right)^{6n-9}\times\left(\frac{1}{\sqrt{12+14}}\right)^{6n-12}\times\left(\frac{1}{\sqrt{14+14}}\right)^{3n^2-12n+12}.$$

$$=\left(\frac{1}{10}\right)^{1}\times\left(\frac{1}{15}\right)^{2}\times\left(\frac{1}{17}\right)^{2}\times\left(\frac{1}{\sqrt{20}}\right)^{1}\times\left(\frac{1}{22}\right)^{3}\times\left(\frac{1}{19}\right)^{3n-4}$$

$$\times\left(\frac{1}{\sqrt{24}}\right)^{6n-9}\times\left(\frac{1}{26}\right)^{3n-6}\times\left(\frac{1}{\sqrt{28}}\right)^{3n^2-12n+12}.$$

Theorem 7: The multiplicative atom bond connectivity ve-degree index of a regular triangulate oxide network $RTOX(n)$ is

$$ABC_{ve}II\left(RTOX\left(n\right)\right)=\left(\frac{8}{25}\right)^{1}\times\left(\frac{13}{50}\right)^{2}\times\left(\frac{3}{14}\right)^{2}\times\left(\frac{17}{84}\right)^{3n-4}\times\left(\frac{3\sqrt{2}}{10}\right)^{1}\times\left(\frac{1}{6}\right)^{3}$$

$$\times\left(\frac{\sqrt{22}}{12}\right)^{6n-9}\times\left(\frac{1}{7}\right)^{3n-6}\times\left(\frac{\sqrt{26}}{14}\right)^{3n^2-12n+12}.$$

Proof: Let G be the molecular graph of a dominating oxide network $RTOX(n)$. By using equation (3) and Table 4, we deduce

$$ABC_{ve}II\left(RTOX\left(n\right)\right)=\prod_{uv\in E(G)}\sqrt{\frac{d_{ve}(u)+d_{ve}(v)-2}{d_{ve}(u)d_{ve}(v)}}$$

$$= \left(\sqrt{\frac{5+5-2}{5\times 5}}\right)^{2} \times \left(\sqrt{\frac{5+10-2}{5\times 10}}\right)^{4} \times \left(\sqrt{\frac{7+10-2}{7\times 10}}\right)^{4} \times \left(\sqrt{\frac{7+12-2}{7\times 12}}\right)^{6n-8} \times \left(\sqrt{\frac{10+10-2}{10\times 10}}\right)^{1}$$

$$\times \left(\sqrt{\frac{10+12-2}{10\times 12}}\right)^{6} \times \left(\sqrt{\frac{12+12-2}{12\times 12}}\right)^{6n-9} \times \left(\sqrt{\frac{12+14-2}{12\times 14}}\right)^{6n-12} \times \left(\sqrt{\frac{14+14-2}{14\times 14}}\right)^{3n^2-12n+12}.$$

$$= \left(\frac{8}{25}\right)^{1} \times \left(\frac{13}{50}\right)^{2} \times \left(\frac{3}{14}\right)^{2} \times \left(\frac{17}{84}\right)^{3n-4} \times \left(\frac{3\sqrt{2}}{10}\right)^{1} \times \left(\frac{1}{6}\right)^{3}$$

$$\times \left(\frac{\sqrt{22}}{12}\right)^{6n-9} \times \left(\frac{1}{7}\right)^{3n-6} \times \left(\frac{\sqrt{26}}{14}\right)^{3n^2-12n+12}.$$

Theorem 8: The multiplicative geometric-arithmetic ve-degree index of a regular triangulate oxide network *RTOX*(*n*) is

$$GA_{ve}II\left(RTOX(n)\right) = \left(\frac{2\sqrt{2}}{3}\right)^{4} \times \left(\frac{2\sqrt{70}}{17}\right)^{4} \times \left(\frac{4\sqrt{21}}{19}\right)^{6n-8} \times \left(\frac{2\sqrt{30}}{11}\right)^{6} \times \left(\frac{2\sqrt{42}}{13}\right)^{6n-12}.$$

Proof: Let *G* be the molecular graph of a regular triangulate oxide network *RTOX*(*n*). By using equation (4) and Table 4, we deduce

$$ABC_{ve}II\left(RTOX(n)\right) = \prod_{uv\in E(G)} \frac{2\sqrt{d_{ve}(u)d_{ve}(v)}}{d_{ve}(u)+d_{ve}(v)}$$

$$= \left(\frac{2\sqrt{5\times 5}}{5+5}\right)^{2} \times \left(\frac{2\sqrt{5\times 10}}{5+10}\right)^{4} \times \left(\frac{2\sqrt{7\times 10}}{7+10}\right)^{4} \times \left(\frac{2\sqrt{7\times 12}}{7+12}\right)^{6n-8} \times \left(\frac{2\sqrt{10\times 10}}{10+10}\right)^{1}$$

$$\times \left(\frac{2\sqrt{10\times 12}}{10+12}\right)^{6} \times \left(\frac{2\sqrt{12\times 12}}{12+12}\right)^{6n-9} \times \left(\frac{2\sqrt{12\times 14}}{12+14}\right)^{6n-12} \times \left(\frac{2\sqrt{14\times 14}}{14+14}\right)^{3n^2-12n+12}.$$

$$= \left(\frac{2\sqrt{2}}{3}\right)^{4} \times \left(\frac{2\sqrt{70}}{17}\right)^{4} \times \left(\frac{4\sqrt{21}}{19}\right)^{6n-8} \times \left(\frac{2\sqrt{30}}{11}\right)^{6} \times \left(\frac{2\sqrt{42}}{13}\right)^{6n-12}.$$

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