แบบจำลองอะตอมโมเลกุลทางเลือกสำหรับการสอน เรื่องทฤษฎีแรงผลักระหว่างคู่อิเล็กตรอนในวงเวเลนซ์

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บทคัดย่อ

แบบจำลองอะตอมโมเลกุลที่ทำจากโฟม เป็นเครื่องมือทางเลือกสำหรับการสอนเรื่องทฤษฎีแรงผลักระหว่างคู่อิเล็กตรอนในวงเวเลนซ์ ซึ่งให้นักเรียนสร้างโมเลกุลที่อะตอมกลางมีอิเล็กตรอนคู่โดดเดี่ยว (ระบบเอบีอี) และอะตอมกลางไม่มีอิเล็กตรอนคู่โดดเดี่ยว (ระบบเอบี) แบบจำลองประกอบด้วยพอลิสไตรีนโฟมใช้แทนธาตุสามัญ เข็มหมุด 2 อันแทนจำนวนอิเล็กตรอนคู่โดดเดี่ยว และไม้จิ้มฟันแทนพันธะ อุปกรณ์ที่จำเป็นต้องใช้ราคาถูกและหาง่าย แต่ในขณะเดียวกันช่วยกระตุ้นให้เกิดการอภิปรายกันในเรื่องรูปร่างโมเลกุล มุมพันธะ จำนวนอิเล็กตรอนคู่โดดเดี่ยวล้อมรอบอะตอมกลาง ขนาดของอะตอม และสีของอะตอม ไม่เหมือนผลิตภัณฑ์ที่ขายตามท้องตลาด แต่ละธาตุไม่มีรูเพื่อเชื่อมต่อ

คำสำคัญ: แบบจำลองอะตอมโมเลกุล ทฤษฎีแรงผลักระหว่างคู่อิเล็กตรอนในวงเวเลนซ์ แบบจำลองอะตอมโมเลกุลจากโฟม

An Alternative Molecular Model for Teaching Valence Shell Electron Pair Repulsion Theory

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Abstract

A foam molecular model is an alternative tool for teaching the valence shell electron pair repulsion theory that allows students to build molecules in which the central atom has lone pair electrons (ABE system) and in which the central atom has no lone pair electrons (AB system). The model consists of different sized and colored polystyrene foam balls representing the common elements, two pins for a number of lone pair electrons, and a toothpick for a bond. The required materials are inexpensive and easy to obtain, but at the same time provide stimulation for discussion about molecular shapes, bond angles, number of electron pairs surrounding the central atom, atomic sizes, and atomic colors, unlike commercial products, each element has no holes to plug in to.

Keywords: Molecular model, Valence shell electron pair repulsion theory, Foam molecular model

Introduction

Valence shell electron pair repulsion (VSEPR) is a simple theory that predicts the molecular shape of covalent compounds (Donaghy and Saxton, 2012; Kemp, 1988). There are two notations for molecular shape, AB and ABE, used in this theory. AB represents the molecular shape in which a central atom has no lone pair electrons and ABE describes the molecular shape that involves lone pair electrons (Chang, 2007). Teachers who teach VSEPR theory say that many students encounter problems understanding three dimensional shapes and to help overcome this, several molecular models have been produced using various materials, such as bouncing balls (Birk, 1988; Figure 1a) and balloons (Niac, 1978). On one hand, these models help students to understand molecular shapes without assistance from teachers as they promote proper placement of atoms in space. On the other hand however, it was found that students neglect discussion and manipulation of bond angles and the ability of electron pairs to repel other groups. Alternative models made of clay (Donaghy and Saxton, 2012; Figure 1b) and foam balls (Pierce, 1959; Figure 1c) encouraged students in discussion and manipulation. A foam molecular model (FMM), consisting of sticks with glue, has limited re-use options and another FMM involves the attachment of small foam balls to larger foam balls with Velcro strips (Kemp, 1988; Figure 1d), but the components of this model are not of standard sizes and colors. Gillespie (1992) reported a model consisting of balloons in which small balloons represent lone pairs of central atoms and attached atoms, but this model requires much time in the inflation of the balloons and these can be easily burst when sharp implements are involved. A ball and stick molecular model clearly explains the geometry of molecules in both the AB and ABE systems (Web Elements Shop, 2014; Figure 1e) and is a common tool in the laboratory used in this study but it is expensive.

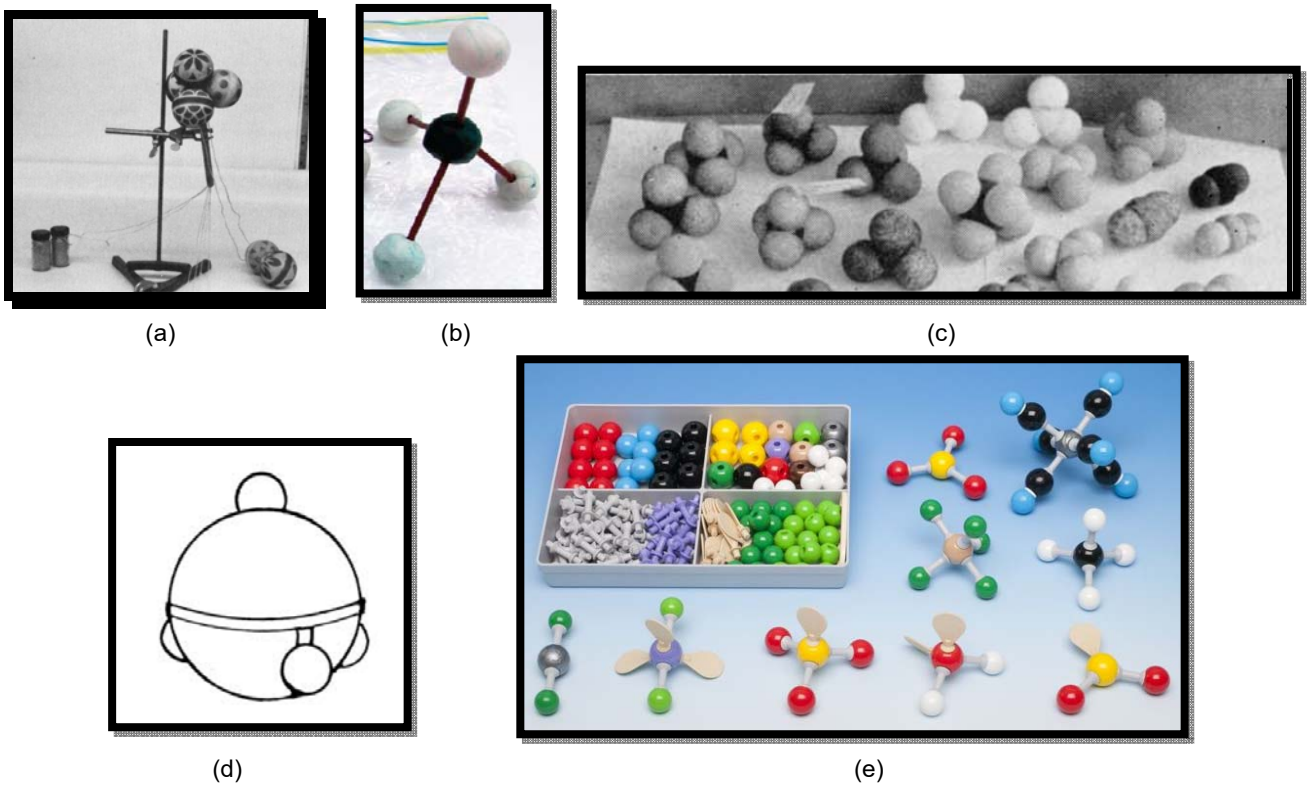

Figure 1 Molecular Models (a) bouncing ball (b) clay (c) foam (d) Velcro strips (e) ball and stick model

This paper outlines an attempt to reduce expenses and increase the applications of both AB and ABE systems by the creation of a FMM with different colored and sized polystyrene balls that are used to represent the atom. A toothpick is used to position the bond pair and two pins are utilized as one lone pair of the central atom.

Materials

A FMM kit contains 5 sizes of different colored polystyrene balls, toothpicks, and pins (Figure 2). The foam balls can be purchased at a craft store and the other materials are readily available.

Figure 2 FMM set

A FMM kit can construct thirteen geometries (Figure 3) of different species according to the VSEPR formula (AB_xE_y), where A is the central atom, B and x are the surrounding atoms and number of them, E represents a lone pair on A, and y is its number (Chang, 2007). For example, SO_2 is a model of AB_2E_1 when A is S, B is O, x is 2, and y is 1.

The model has five different sized balls (0.8, 1, 1.2, 1.4, and 1.6 inches) and elements that are in the same period of the periodic table are represented by the same size ball (see Table 1). One toothpick is inserted into a foam ball, the ball is painted with acrylic color according to the Corey-Pauling-Koltun molecular models (Wikipedia, 2014), and left to dry.

Table 1 Minimum quantity, ball size, and color for each element in FMM kit

Element	Minimum quantity	Actual atomic size (pm)	Ball size (diameter)	Color
H	3	37	0.8	White
F	6	72	1.0	Light green
O	2	73	1.0	Red
N	1	75	1.0	Blue
C	1	77	1.0	Black
B	1	85	1.0	Peach
Cl	5	99	1.2	Medium green
S	1	103	1.2	Yellow
P	1	110	1.2	Orange
Br	1	114	1.4	dark red
Xe	1	131	1.6	Cyan
I	1	133	1.6	dark violet

Conclusion

There are various molecular models for VSEPR theory. The FMM outlined in this paper is an alternative model that is cheap and can be created by students. The use of FMM to visualize AB and ABE systems in VSEPR theory required teacher-students and/or peer discussion issues related to bond angles and bond lengths. The FMM promotes hands-on activity in the classroom and quickly reveals preconceptions and misconceptions about chemical bonding for formative and summative assessment by decreasing the time to assemble the model but increasing the time to think how to assemble it to correspond to VSEPR theory.

Recommendations

It is recommended that teachers should use this model to teach the physical properties of elements which students will be studying prior to chemical bonding.

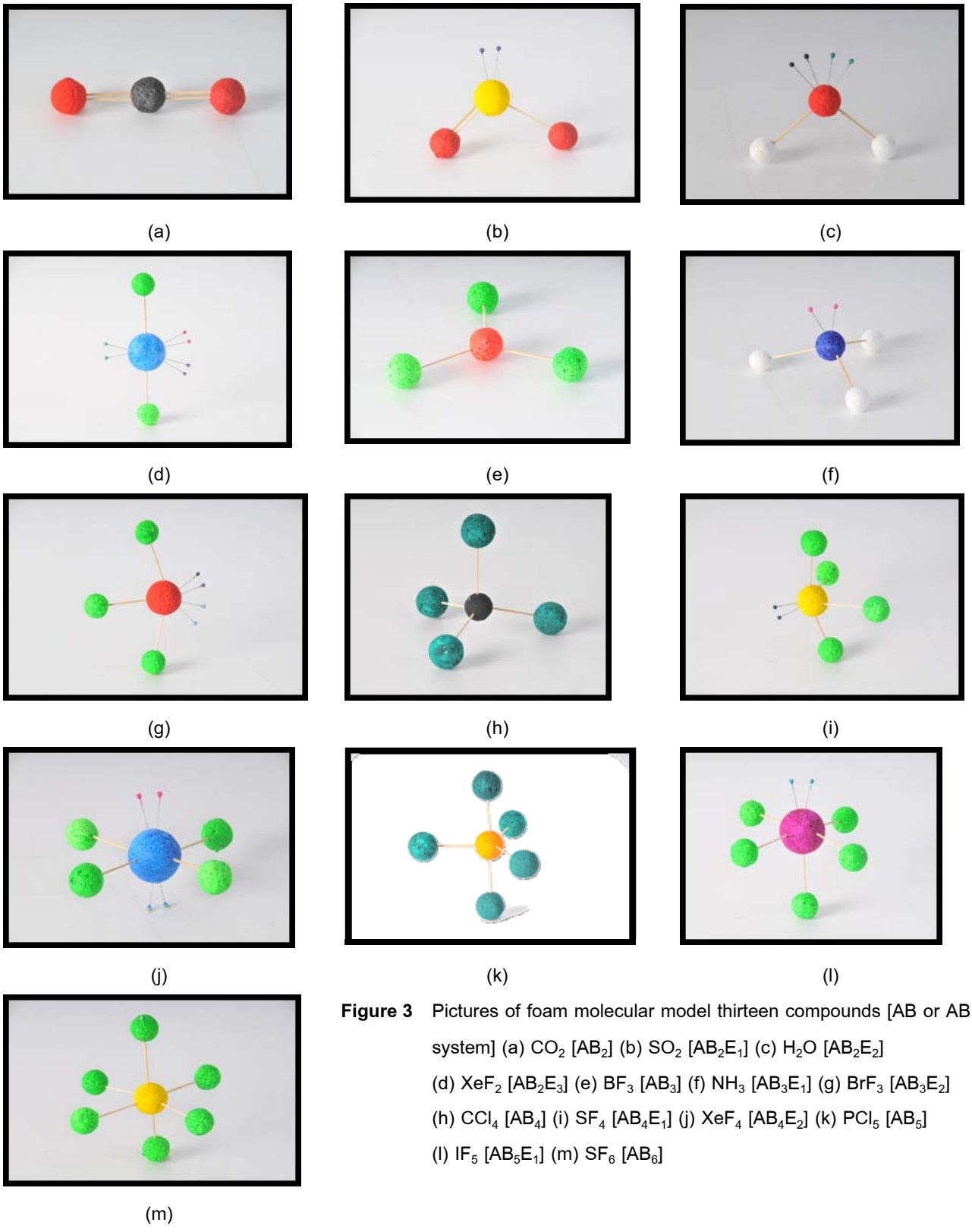

Figure 3 Pictures of foam molecular model thirteen compounds [AB or ABE system] (a) CO_2 [AB_2] (b) SO_2 [AB_2E_1] (c) H_2O [AB_2E_2] (d) XeF_2 [AB_2E_3] (e) BF_3 [AB_3] (f) NH_3 [AB_3E_1] (g) BrF_3 [AB_3E_2] (h) CCl_4 [AB_4] (i) SF_4 [AB_4E_1] (j) XeF_4 [AB_4E_2] (k) PCl_5 [AB_5] (l) IF_5 [AB_5E_1] (m) SF_6 [AB_6]

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