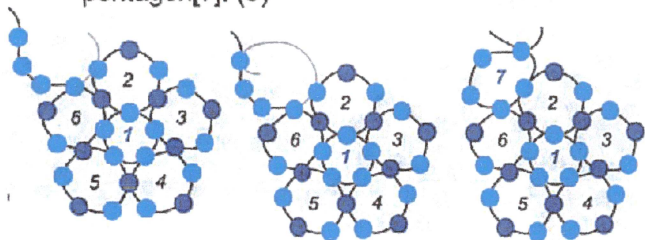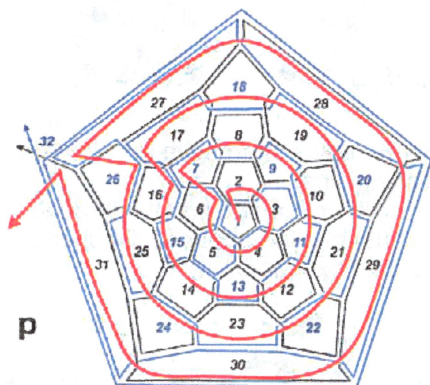14. Add 3 beads, AAA, on the non-fishing line. Take the other line and insert it through the furthest bead in the opposite direction and pull the lines tight. This makes a second pentagon[7]. (o)

15. Go fishing (through one, two or three beads, as necessary) and complete two sets of alternating pentagons and hexagons around the original pentagon[8 to 26]. (p)

p

'String path' Schlegel diagram of C60 with spiral code:
[1 7 9 11 13 15 18 20 22 24 26 32]

16. The last set will be five hexagons[27 to 31] where the last bead will simultaneously close the final hexagon[31] and the final pentagon[32] to complete C60.

17. Fish one line around the pentagon to a common vertex and tie a knot. Fish the lines again through some beads to hide the knot. Use the remaining line to hang your C60 or cut the lines
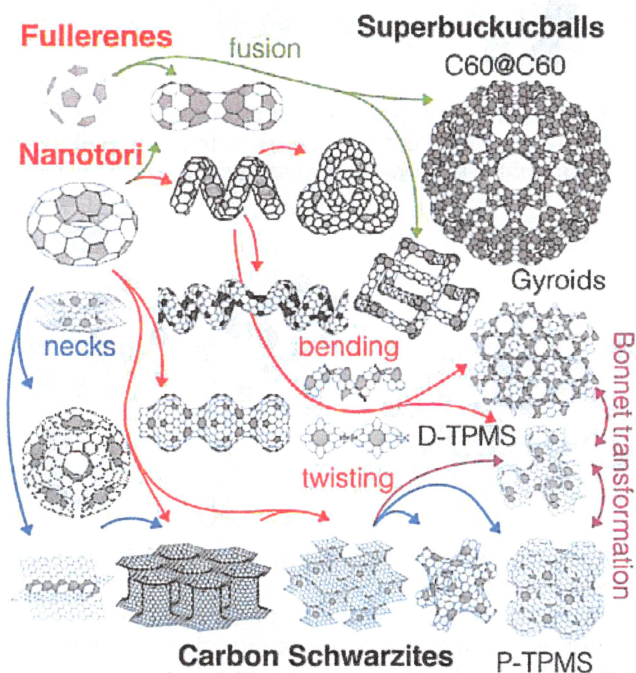
Other structures and references

It is possible to make physical models of many other molecules and nano-structures with the technique of mathematical beading. For more examples, check the beaded molecules blog:
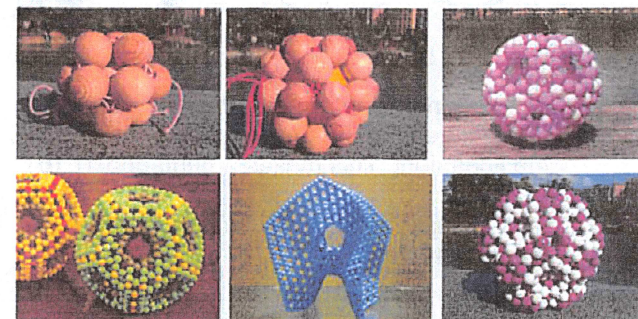http://thebeadedmolecules.blogspot.com

1. Jin, B.-Y. et al., CHEMISTRY (The Chinese Chemical Society, Taipei) 2008, 66, 73-92.

2. Jin, B.-Y. et al., J. Chin. Chem. Soc. 2010, 57, 316-324.

3. Jin, B.-Y. et al., Proc. of Bridges: Mathematics, Music, Art, Architecture, Culture, 2010, 391-394.

4. Chuang, C. et al., Proc. of Bridges: Mathematics, Music, Art, Architecture, Culture, 2011, 523-526.

5. Chuang, C. et al., J. Chem. Edu. 2012 , 89 (3), 414–416.

6. Tsoo, C.-C. et al., Proc. of Bridges: Mathematics, Music, Art, Architecture, Culture, 2013, 495-498.

Graphitic structures

Fullerenes — fusion → Superbuckucballs C60@C60
Nanotori
necks
bending
D-TPMS
twisting
Gyroids
Bonnet transformation
Carbon Schwarzites   P-TPMS

The Fabulous World of Beaded Molecules

Bih-Yaw Jin 金必耀 , NTU (byjin@ntu.edu.tw)
Chia-Chin Tsoo 左家靜, NCHC (cct@nchc.narl.org.tw)

Molecular Modelling of C60 with Beads

Choose 2 bead colors – for C60 you need 60 beads of color A (light, for example) and 30 beads of color B (dark) – Note that pentagons will be in color A. You will need a length of nylon fishing line approximately 400 times of the length of a single bead.

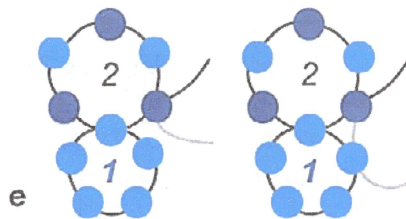1. String 5 beads of color A in the middle of the line. (a)

a   b
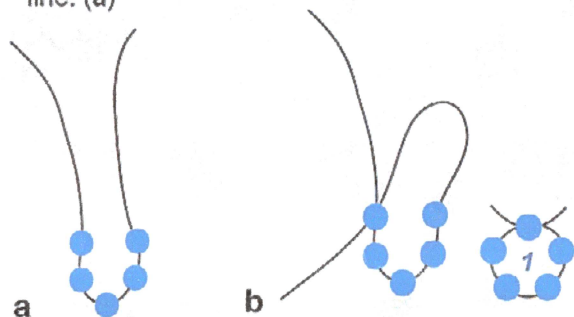
2. Take the right line and insert it through the furthest bead in the opposite direction and pull the lines tight. This makes a pentagon[1]. (b)

3. Add 5 beads alternating in color, BABAB, on the left line. (c)
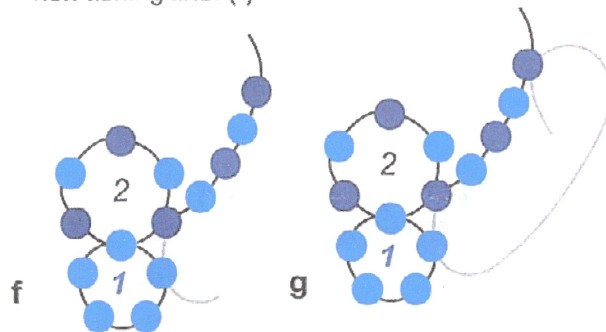

c   d
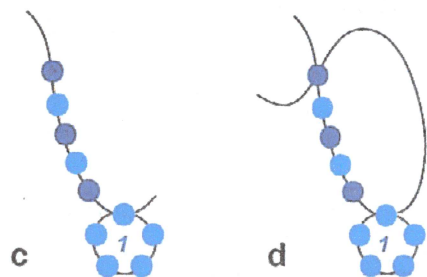
4. Take the opposite line and insert it through the furthest bead in the opposite direction and pull the lines tight. This makes a hexagon[2]. (d)

5. In order for the next hexagon to be fused with the existing rings, the line must exit from neighboring rings. Therefore, insert the line at the pentagon junction through the closest pentagon bead - this is called fishing. (e)
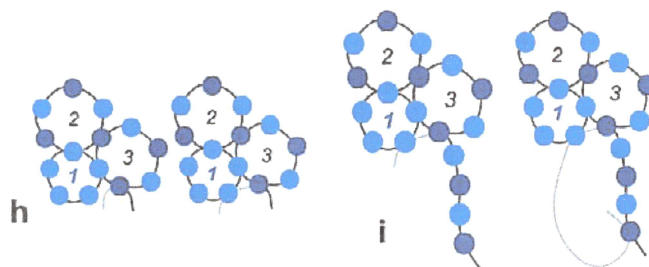

e

6. Add four beads alternating in color, ABAB, on the non-fishing line. (f)
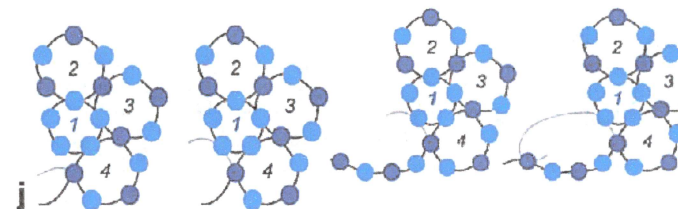

f   g

7. Take the other line and insert it through the furthest bead in the opposite direction and pull the lines tight. This makes a hexagon[3]. (g)
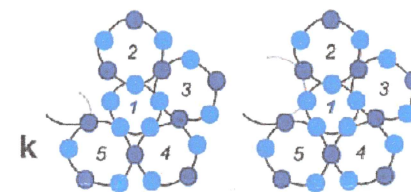
8. Go fishing. (h)

h   i

9. Add four beads alternating in color, ABAB, on the non-fishing line.
Take the other line and insert it through the furthest bead in the opposite direction and pull the lines tight. This makes a hexagon[4]. (i)

10. Repeat steps 8 & 9 to make the fourth hexagon[5]. (j)
Notice that the **fishing** and **non-fishing** lines will always alternate and both lines should decrease in length equally.

j

11. Go fishing twice. (k)

k

12. Add three beads alternating in color, ABA, on the non-fishing line.
Take the other line and insert it through the furthest bead in the opposite direction and pull the lines tight, hexagon[6]. (l)

l
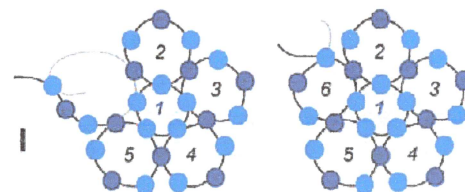
13. Go fishing. (m)
This structure is corannulene. (n)

m   n