C0r0n@ 2 Inspect

Review and analysis of scientific articles related to experimental techniques and methods used in vaccines against c0r0n@v|rus, evidence, damage, hypotheses, opinions and challenges.

Thursday, December 16, 2021

Evidence found confirming the theory of human body-centered nanonetworks: nano-rectennas

Research on nanocommunication networks for nanodevices inoculated into the human body continues to add evidence. Here we present the paper by researchers (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) entitled "*Nano-rectenna powered body-centric nano-networks in the terahertz band*" where the theory that Corona2Inspect had been studying through the observation of the images of the c0r0n@v|rus vaccine samples obtained by Dr. (Campra, P. 2021) is confirmed. The human body-centered nanonetworks require the use of nano-antennas operating in the terahertz band, these being of the same type as those found in the vaccine samples. In the literature these plasmonic nano-antennas are also called bowtie antennas and in the article in question they are called "*nano-rectennas*". The explicit mention of the type of antenna and intra-body nano-network technology would confirm that vaccines are, among other things, vectors for installing nanotechnology, or nano-devices in the human body. However, beyond pure coincidence, the authors make explicit the use of graphene and carbon nanotubes as necessary elements for this network model, elements that were also identified in the images taken by Dr. Campra and that coincide with the presence of graphene in his technical report with Micro-Raman spectroscopy. To what has already been described, the article adds that the method of communication and data transmission in the nanonetworks is carried out through TS-OOK signals (sequences of pulses that transmit binary codes), which coincides with the studies and protocols of nanocommunications and would endorse all the research carried out by Corona2Inspect so far in this area. If what has been explained is not enough to confirm the theory of intrabody communication nanonetworks, the article by (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) makes explicit the use of nano-sensors that are linked by electromagnetic signals, by means of the aforementioned nano-rectennas or bowtie nano-antennas, which necessarily evidences the presence of nano-routers that serve to manage the intra-body and out-of-body data link, with gateways such as the cell phone. Given the importance of the contents of the article, we will proceed to its detailed dissection.

Analysis of the article

The research object of the paper by (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) is the comparative analysis of the energy harvesting capabilities of nano-rectennas, aimed at their implementation in wireless nanodevice networks and intra-body nanotechnology. This is reflected in the introduction of the article as follows "*in the field of healthcare applications, the goal is to develop a network of therapeutic nanodevices that is capable of working on or within the human body to support immune system monitoring, health monitoring, drug delivery systems, and biohybrid implants*." This leaves no doubt that nano-antennas, here referred to as nano-rectennas, necessarily imply the presence of a network of nanodevices or nanotechnology aimed at monitoring biological variables and factors in people.

Furthermore, (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) state that "*there are two main approaches for nanoscale wireless communications, i.e., molecular and electromagnetic (EM) communications (Akyildiz, I.F.; Jornet, J.M. 2010). The latter commonly operates in the terahertz (THz) band (0.1-10 THz) and is a promising technique to support data exchange in nanosensor networks for healthcare applications or body-centric nano-networks. For the expected size of nanosensors, the frequency radiated by their antennas would normally be in the optical range, resulting in a very large channel attenuation that could make nanoscale wireless communication infeasible. To overcome this limitation, graphene-based antennas have been developed, which are capable of resonating in the THz band with sizes of a few* μm*, at a frequency up to two orders of magnitude lower than a metallic antenna of the same dimensions*." This explanation corroborates the two types of intra-body communication, the molecular type used for monitoring and neuromodulation of neuronal tissue and the central nervous system (Akyildiz, I.F.; Jornet, J.M.; Pierobon, M. 2011 | Malak, D.; Akan, O.B. 2012 | Rikhtegar, N.; Keshtgary, M. 2013 | Balasubramaniam, S.; Boyle, N.T.; Della-Chiesa, A.; Walsh, F.; Mardinoglu, A.; Botvich, D.; Prina-Mello, A. 2011) and electromagnetic, conceived for monitoring biological variables and factors in the rest of the body, by means of nano-nodes (also known as nano-devices, nano-biosensors, etc.). It also corroborates the operating band in which the intra-body nano-network is operative, in the range of 0.1-10 THz, confirmed in this blog according to (Abbasi, Q.H.; Nasir, A.A.; Yang, K. ; Qaraqe, K.A.; Alomainy, A. 2017 | Zhang, R.; Yang, K.; Abbasi, Q.H.; Qaraqe, K.A.; Alomainy, A. 2017 | Yang, K.; Bi, D.; Deng, Y.; Zhang, R.; Rahman, M.M.U.; Ali, N.A.; Alomainy, A. 2020). It also addresses the fact that the scale of nano-devices, nano-sensors in the network forces to "resonate the THz band" by special antennas of a few microns (μm), but with the ability to retransmit signals and in turn to collect energy to make the network work. These special properties, are achieved by means of the plasmonic effect given by the scale of nanoantennas, which confers special physical and quantum properties to these objects, as explained in (Jornet, J.M.; Akyildiz, I.F. 2013 | Nafari, M.; Jornet, J.M. 2015 | Guo, H.; Johari, P.; Jornet, J.M.; Sun, Z. 2015).

In the introductory dissertation, (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) mention a substantial aspect "*information exchange between implantable [injectable] nanosensors is the most significant, as it enables the control and tracking of molecular release or flow, biochemical compounds and other important functions within the human body*." The relevance of this statement is crucial as it implies that nanodevices have to be installed, injected or implanted into the human body, but also that it is necessary to receive their generated signals and data to do the corresponding monitoring, even at the level of molecular flow and biochemical compounds, as is the case with neurotransmitters produced by neural tissue or the nervous system (Abd-El-atty, S. M.; Lizos, K.A.; Gharsseldien, Z.M.; Tolba, A.; Makhadmeh, Z.A. 2018). This explains the need to introduce graphene, carbon nanotubes and derivatives to capture these signals and bio-electrical markers to capture the information, but also a wireless nano-network, which allows transmitting these data to the outside of the human body. Therefore, it must be understood that the nano-antennas or nano-rectennas in charge of repeating the signals could not only do it from the inside to the outside, being able to carry out the inverse process, altering the neuronal synapse, for example.

Likewise, (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) state that a relevant problem in intra-body nano-networks is the availability of energy (Bouchedjera, I.A.; Aliouat, Z.; Louail, L. 2020 | Fahim, H.; Javaid, S.; Li, W.; Mabrouk, I. B.; Al-Hasan, M.; Rasheed, M.B.B. 2020), for which efficient routing protocols and processes have been developed (Sivapriya, S.; Sridharan, D.

2017 | Piro, G.; Boggia, G.; Grieco, L.A. 2015) that make the operation of the nano-grid plausible. For the purpose of nano-antennas or nano-rectennas, Rong and his team state the following, "*One of the biggest challenges in body-centered nano-networks is caused by the very limited energy storage of a nano-battery.... Since electromagnetic waves carry not only information but also energy, rectennas can operate at THz and microwave frequencies, allowing them to work overnight. Since electromagnetic waves carry not only information but also energy (Varshney, L.R. 2008), nano-rectennas can share the same signal that is used to carry information within nano-networks. As a result, simultaneous wireless information and power transfer (SWIPT) becomes a fundamental technique for powering nano-networks and is a promising solution to power bottlenecks..... A major advantage of the technique is that the proposed nano-grids are capable of converting an EM signal into a DC current without any external power supply to the system. In addition, the achievable power conversion obtains an efficiency of approximately 85%.*" These statements are fundamental for confirming that EM electromagnetic waves, or in other words microwaves, can transport energy and data simultaneously, being able to do so in the THz band compatible with the intra-body wireless network. This confirms what was explained in the entry on nanocommunication networks for nanotechnology in the human body, published in this blog. This ambivalent phenomenon of transporting energy and data is known by the acronym SWIPT, which allows inferring that nano-antennas or nano-rectennas have this property. In fact, the authors claim their ability to convert an EM signal into direct current without external power supply, with a very high efficiency, which would explain that enough energy is generated and probably stored to operate the intra-body network. In fact, according to (Zainud-Deen, S.H.; Malhat, H.A.; El-Araby, H.A. 2017) nanoantennas with a geometrical diode such as bowtie or other polygonal type, based on graphene, not only collect energy from EM electromagnetic waves (microwaves), they can also do so with the infrared spectrum (El-Araby, H. A.; Malhat, H.A.; Zainud-Deen, S.H. 2017 | 2018), which guarantees a constant flow of energy.

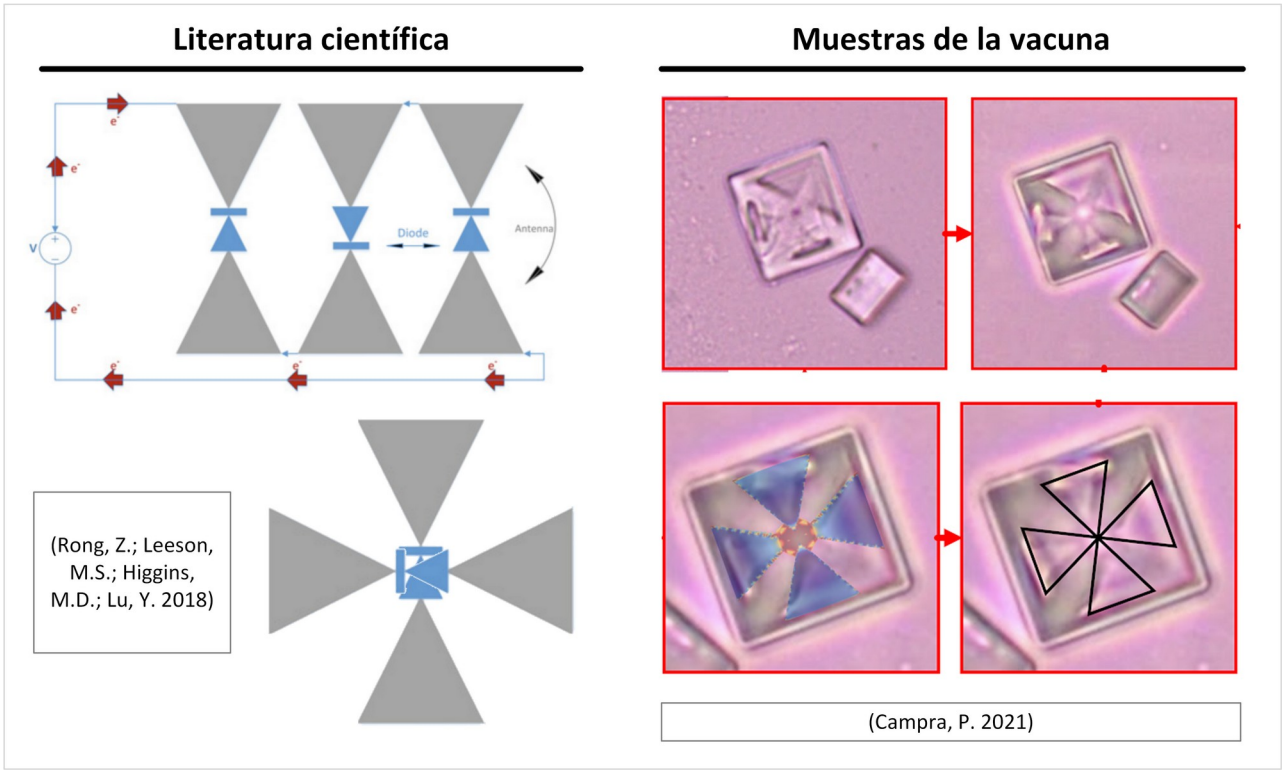


Fig.1. Nano-rectenas in array and double bow-tie composition, similar to that found in the Pfizer vaccine samples analyzed by Dr. Campra.

On the other hand, (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) define the rectenna concept as "*a combination of an antenna and a rectifying device, usually a diode, for the purpose of harvesting energy in and for the nanonetworks, such that EM waves are received by a nano antenna and then coupled to a rectifier... this makes them usable for harvesting THz and higher frequency energy. As the nano-sized antennas operate in the THz band, their associated rectifier diodes need a fast response so that they can react properly to the incoming signal and deliver a DC (Direct Current) signal.... The rectenna can harvest energy from the THz signal or from residual energy in the environment*". However, it is known that rectennas are also capable of transmitting and collecting energy and data in the GHz band as explained in the work of (Suh, Y.H.; Chang, K. 2002 | Abdel-Rahman, M.R.; Gonzalez, F.J.; Boreman, G.D. 2004). Also noteworthy in this aspect is the work of (Khan, A.A.; Jayaswal, G.; Gahaffar, F.A.; Shamim, A. 2017) in which it is demonstrated that nano-rectennas are capable of harvesting energy from ambient radio frequency (RF) for which they employ tunneling diodes, which consume hardly any energy during the process of conversion to direct current. These tunneling diodes also known as MIM (metal-insulator-metal) diodes can provide zero bias rectification, allowing them to operate in a frequency range between 2-10GHz, which allows them to match the input impedance. In fact, Khan and his team state that "*Although the real advantage of MIM diodes is at high frequencies (THz range), their zero-bias rectification capability can also be beneficial for harvesting and wireless power at RF frequencies.... DC (Direct Current) characterization indicated that the MIM diode could provide a zero bias response capability of 0.25V -1 with a decent dynamic resistance of 1200 Ω (Ohms). RF (Radio Frequency) characterization of metal-insulator-diode-metal was performed using two methods: 1) S-parameter (Diode Tunnel Barrier Thickness) measurements from 500MHz to 10 GHz, and 2) From RF to DC rectification with zero bias. The presented input impedance results may be useful for the integration of MIM diodes with antennas for harvesting applications. The second part of the RF characterization verified the RF-to-DC rectification of zero bias*." In other words, the researchers confirm that nano-rectennas can operate in lower frequency ranges and even by radio frequency, which explains why it makes them the ideal method for powering wireless nanonetworks and their IoNT (Internet of NanoThings) connection applications.

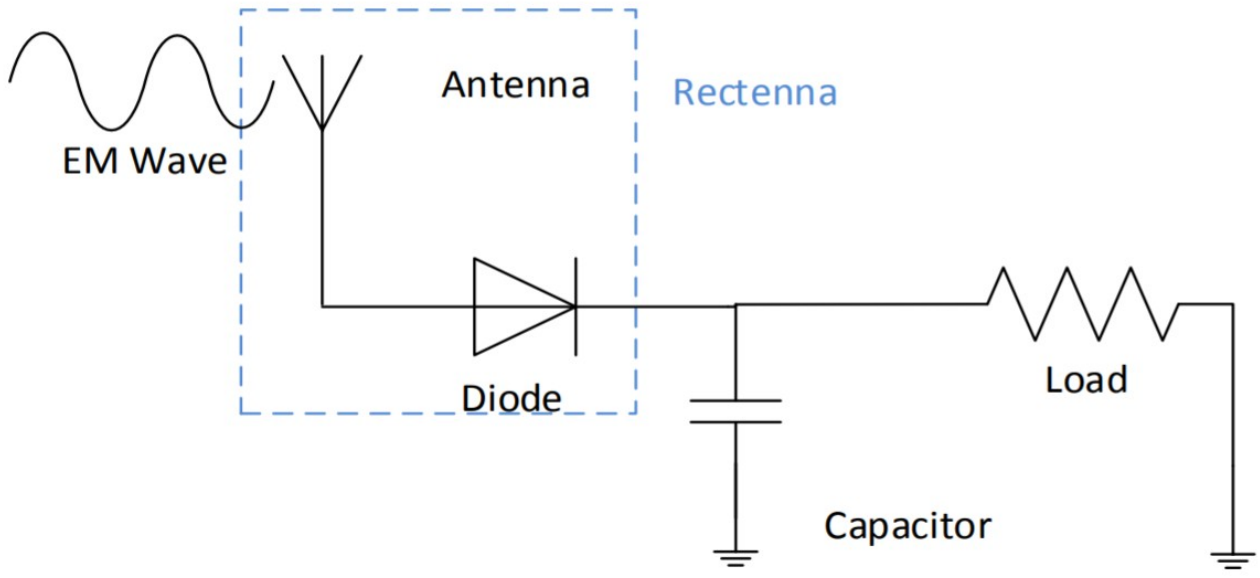


Fig.2. Circuit diagram of a rectenna with its basic elements. (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018)

Turning to the analysis of (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018), their work addresses the comparison of two types of intra-body nano-network oriented rectennae. One of them is the carbon nanotube-based nano-rectenna, which matches the identifications observed in the vaccine samples. In this regard, Rong and his team cite the work of (Sharma, A.; Singh, V.; Bougher, T.L.; Cola, B.A. 2015) who proposed CNT (Carbon Nanotube) rectennas "*which consisted of millions of nanotubes functioning as nano-antennas, with their tips made of Insulator-Metal (IM) to behave as diodes. The CNT rectennas showed great potential for body-centric nanodevice applications and wireless EM energy harvesting*." This could confirm that the observed carbon nanotubes and plasmonic nanoantennas are intended, among others, to supply energy to the nano-network installed with the various inoculations of the vaccine, an aspect that would explain the need for several doses until completing the basic energy supply for its perpetual operational maintenance. Elaborating on carbon nanotube rectennas, it is also stated that "*When CNTs absorb EM radiation, a direct current will be generated after rectification by the tip area. This converted current is used to charge a capacitor. The DC (Direct Current) conversion process is carried out using the THz signal inside the system and ambient free EM, so the power source of such a nano-rectenna generator does not need another specific external power source*." This suggests that no other components are required for operation.

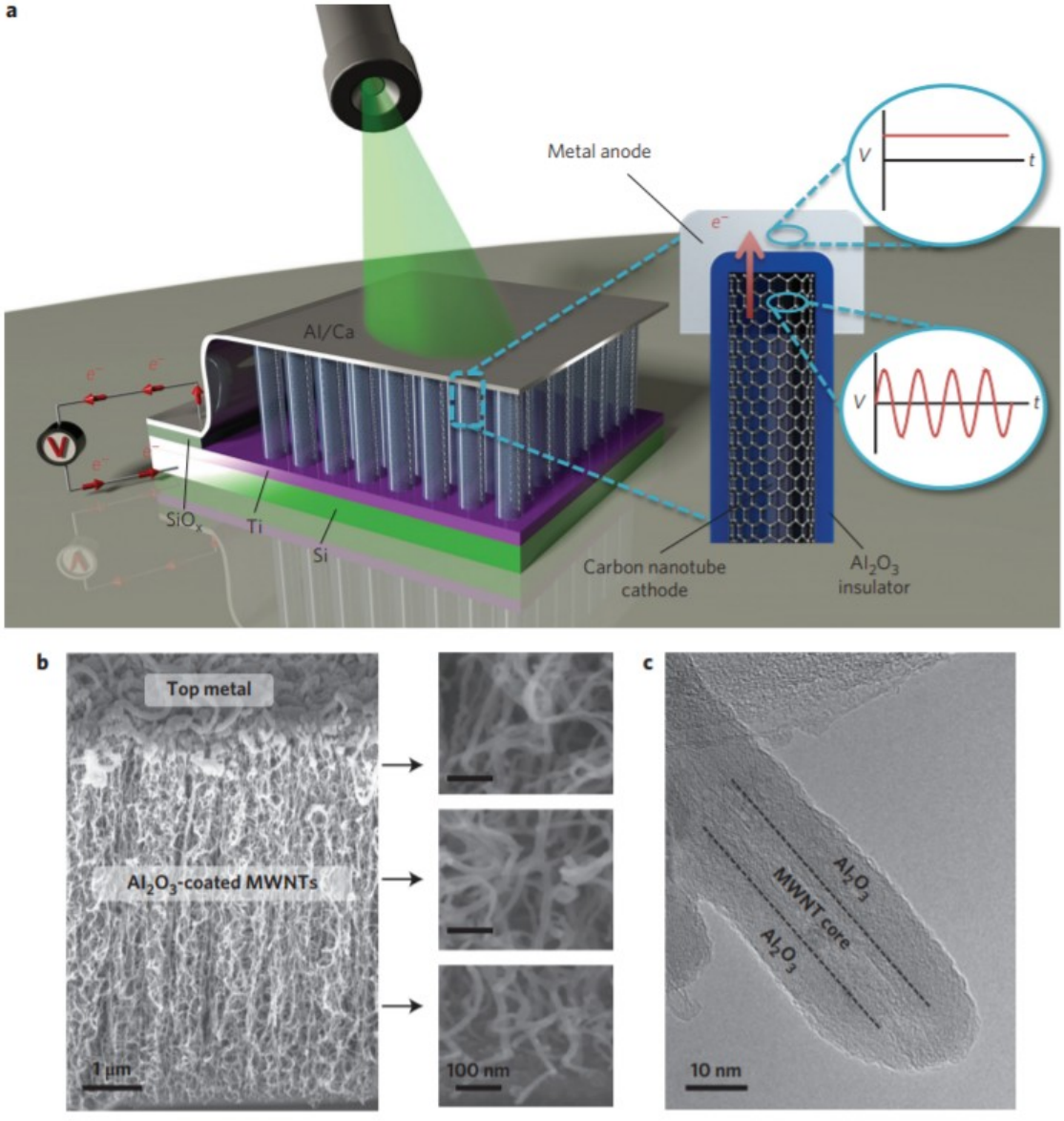
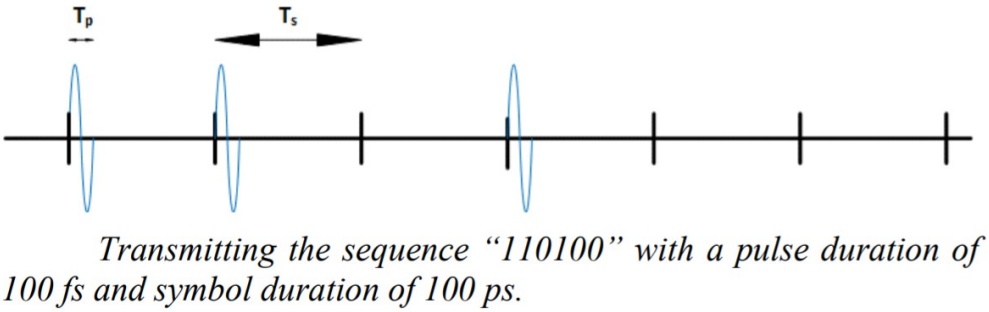


Fig.3. Nano-rectenna formed by multi-walled carbon nanotubes encapsulated in a sandwich of metallic nanomaterials. (Sharma, A.; Singh, V.; Bougher, T.L.; Cola, B.A. 2015)

In addition to CNT nano-rectennas, (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018) compare them to their main proposal, bow-tie nano-rectennas "*bow-tie dipole nano-rectennas, with two triangular sections, have been proposed. The thickness of the antenna is 100 nm, and the nano-diodes, made of graphene located in the middle of the bow-tie antenna gap area, producing the rectenna action. Additionally, it can be connected to form an array of nano-rectennas. The bowtie dipole antenna receives EM radiation and converts the signal into AC (alternating current) flow to the nano-diode. The diode then rectifies the AC (alternating current) into DC (direct current).*" This would confirm the type of plasmonic nano-antennas observed in the vaccine samples, as well as the graphene material used as a nexus between its triangular sections, which coincides with the presence of graphene detected by Campra in the vaccines. Another relevant detail is also provided, the nano-rectennas can operate in matrix or array, which means that thousands of them can operate, as Rong and his team state "*As the output power of a single rectenna is 0.11 nW (approximately), if we use an array of these rectennas, the power and size required by the nano-grid can be satisfied.... More elements connected in series can increase the current and power output*." This is demonstrated in the work of (Aldrigo, M.; Dragoman, M. 2014) entitled "*Graphene-based nano-rectennas in the far-infrared frequency band*" where it is made explicit that nano-rectennas are capable of harvesting human heat in the infrared frequency band, and that the proposed model is encouraging "*both in terms of rectified current from a single nano-rectenna, and rectified power from a macro-system combining thousands of nano-rectennas*." Which leaves no doubt that nano-rectennas are not an isolated component, in fact they are more common and numerous than might a priori be thought. Perhaps one dose of the vaccine involves thousands or perhaps millions of nano-rectens, depending on its scale.

Rong's article continues to provide very relevant clues, this time in relation to CNT rectennae, stating that "*the output voltage generated by the CNT rectenna is of the order of tens of millivolts... the channel access scheme for communications will be based on femtosecond pulses to the nanonet. ... the digits 1 (of the binary code) are transmitted using 100 f s pulses, that is a long pulse, while the digits 0 are transmitted as a silence... as the separation time between adjacent bits is 1000 times the pulse duration (Ts = 100ps), the average power will return to the nW level. Therefore, the output power of the CNT rectenna is able to satisfy the power requirements of the system (of the nanonetwork)*." This statement confirms what Corona2Inspect already inquired, nanonetworks operate with TS-OOK signals for data packet transfer (see nanocommunication networks for nanotechnology in the human body, CORONA system for nanonetworks, nanorouters, electromagnetic nanonetwork software) because of their simplicity and reduced power consumption. It also confirms that carbon nanotubes can operate in signal and data transmission, as well as energy harvesting, as suggested in the post on nanooctopuses and carbon nanotubes in this blog.



Transmitting the sequence "110100" with a pulse duration of 100 fs and symbol duration of 100 ps.

Fig.4. TS-OOK pulses transmitting binary code of the signals obtained in the nanonetwork. (Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. 2018)

According to Rong's calculations, "*For a CNT rectenna device, the maximum reported output voltage is 68 mV and for a 25-element bowtie rectenna array it is 170 mV. Therefore, according to (9), the bowtie rectenna array (bowtie) delivers more charge than the CNT rectenna...when these two rectenna devices are used to charge the same ultracapacitor (9nF), it is evident that the CNT rectenna takes longer (more than 6 minutes) due to its very high junction resistance. Whereas for the rectenna bowtie, the resistance is comparatively very small, so it only takes about 6 ms to supply more power to the capacitor*." This explanation is very important when comparing the two types of rectenna for intra-body nano-networks. Array bowtie nano-rectennas present better performance than those based on carbon nanotubes, taking only 6 milliseconds to charge a nano-capacitor. This would explain the presence of these components in the vaccine samples, at micro- and nano-scale. In addition, the allusion to the ultra-nanocapacitors used to perform the charging test is relevant. Capacitors are passive electrical devices capable of storing energy by maintaining an electric field. This may raise the question: where is the energy stored in the intra-body nanonetworks? The answer is very simple, in an abundant and recognized material in vaccines, namely graphene itself. Graphene nanosheets and meshes can perform the function of capacitors, as reported in the work of (Bai, J.; Zhong, X.; Jiang, S.; Huang, Y.; Duan, X. 2010), because "*graphene sheets in nano-ribbons with widths of less than 10 nm can open a band gap large enough for operation as a transistor at room temperature*" this is de facto what allows generating a magnetic field, as a result of the electric charge transmitted by the nano-rectennas. This would explain the phenomenon of magnetic arms (among other parts of the body) after inoculation of vaccines. In fact, if you look at Figure 5, you can see a nano-mesh (graphene) similar to the one in the scientific literature, which could act as a capacitor. In many cases these shapes were found around polygonal, quadrangular and nano-antennas objects, which seems to make sense to provide an energetic remnant for the nano-networks.

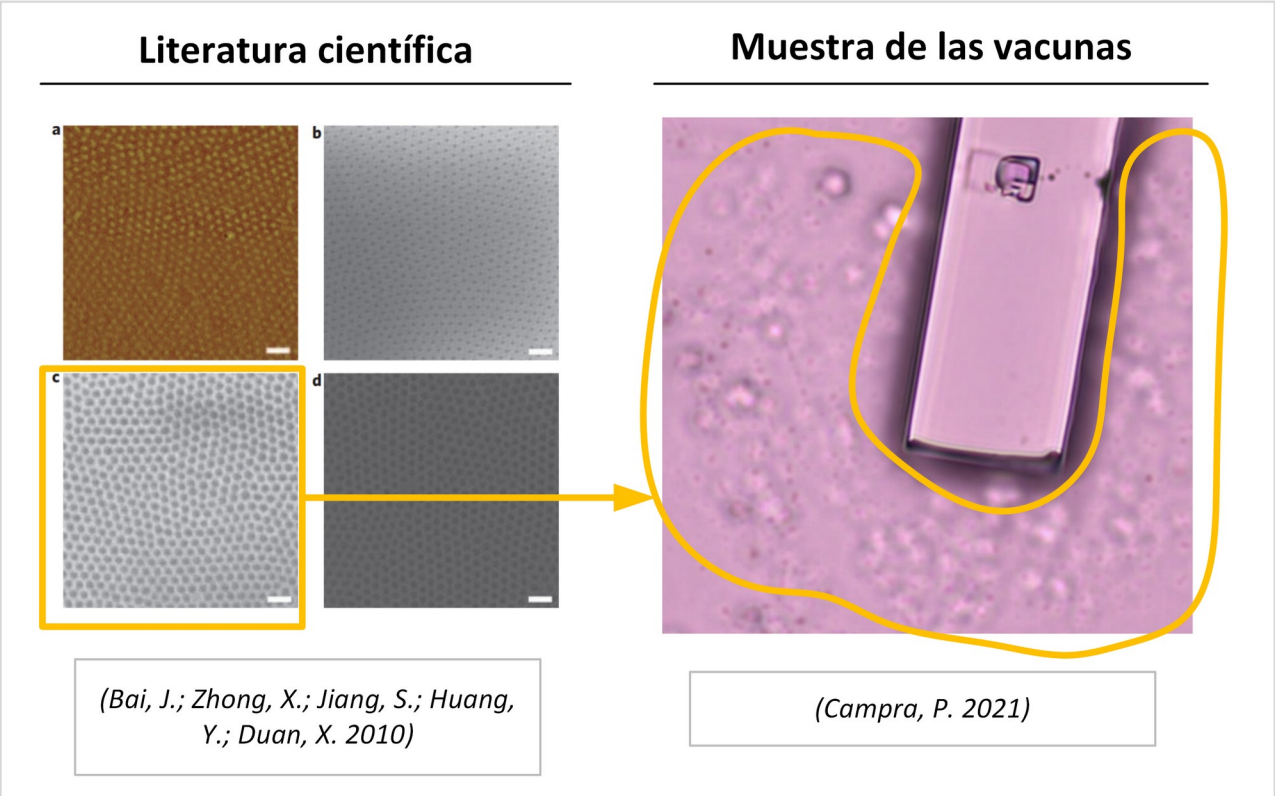


Fig.5. In the Pfizer vaccine samples, a graphene mesh appears to be observed around the crystals, nano-cubes and polygonal structures where the nano-antennas were found, although diffused. (Bai, J.; Zhong, X.; Jiang, S.; Huang, Y.; Duan, X. 2010)

Finally, among the conclusions, Rong and his team highlight the following "*Together with the continuous advancement of SWIPT (simultaneous wireless information and power transfer) technique, the pioneering CNT array rectenna and bowtie array nano-rectenna open the door for wireless powering of nanosensors. Since a nano-rectenna is capable of powering nanosensors without any external source and its broadband property allow the rectenna to be a very efficient and promising way to power implanted nanodevices and in the human body. The CNT rectenna array can successfully supply the required power of the human body-centered wireless nanonetwork, estimated at around 27.5 nW. In addition, the bowtie rectenna array are much smaller in size, but provide similar power.... Although nano-rectennas cannot provide such a high voltage compared to a piezoelectric nanogenerator, a bowtie nano-rectenna array is much more efficient by also producing DC (Direct Current) directly from the THz signal within the system (the human body) and the ambient EM signal without any other external power supply to the system*." This seems to make it clear that this type of nano-antennas are the right ones, if what is desired is to install intra-body nano-networks of nanodevices and nanosensors. Therefore, it does not take a very sharp deduction to realize that the presence of plasmonic nano-antennas in the vaccine samples, whether in the form of a bow tie or a cube, or a prism, as has been observed, is clear evidence of the presence of undeclared nanotechnology.

Bibliography

1. Abbasi, Q.H.; Nasir, A.A.; Yang, K.; Qaraqe, K.A.; Alomainy, A. (2017). Cooperative in-vivo nano-network communication at terahertz frequencies. IEEE Access, 5, pp. 8642-8647. https://doi.org/10.1109/ACCESS.2017.2677498
2. Abd-El-atty, S.M.; Lizos, K.A.; Gharsseldien, Z.M.; Tolba, A.; Makhadmeh, Z.A. (2018). Engineering molecular communications integrated with carbon nanotubes in neural sensor nanonetworks. IET Nanobiotechnology, 12(2), 201-210. https://ietresearch.onlinelibrary.wiley.com/doi/pdfdirect/10.1049/iet-nbt.2016.0150
3. Abdel-Rahman, M.R.; Gonzalez, F.J.; Boreman, G.D. (2004). Antenna-coupled metal-oxide-metal diodes for dual-band detection at 92.5 GHz and 28 THz. Electronics Letters, 40(2), pp. 116-118. https://sci-hub.mksa.top/10.1049/el:20040105
4. Akyildiz, I.F.; Jornet, J.M. (2010). Electromagnetic wireless nanosensor networks. Nano Communication Networks, 1(1), pp. 3-19. https://doi.org/10.1016/j.nancom.2010.04.001
5. Akyildiz, I.F.; Jornet, J.M.; Pierobon, M. (2011). Nanonetworks: A new frontier in communications. Communications of the ACM, 54(11), pp. 84-89. https://doi.org/10.1145/2018396.2018417
6. Aldrigo, M.; Dragoman, M. (2014). Graphene-based nano-rectenna in the far infrared frequency band. En: 2014 44th European Microwave Conference (pp. 1202-1205). IEEE. https://doi.org/10.1109/EuMC.2014.6986657 | https://sci-hub.mksa.top/10.1109/eumc.2014.6986657
7. Bai, J.; Zhong, X.; Jiang, S.; Huang, Y.; Duan, X. (2010). Graphene nanomesh. Nature nanotechnology, 5(3), pp. 190-194. https://doi.org/10.1038/nnano.2010.8 | https://sci-hub.mksa.top/10.1038/nnano.2010.8
8. Balasubramaniam, S.; Boyle, N.T.; Della-Chiesa, A.; Walsh, F.; Mardinoglu, A.; Botvich, D.; Prina-Mello, A. (2011). Development of artificial neuronal networks for molecular communication. Nano Communication Networks, 2(2-3), pp. 150-160. https://doi.org/10.1016/j.nancom.2011.05.004

9. Bouchedjera, I.A.; Aliouat, Z.; Louail, L. (2020). EECORONA: Energy Efficiency Coordinate and Routing System for Nanonetworks. En: International Symposium on Modelling and Implementation of Complex Systems. Cham. pp. 18-32. https://doi.org/10.1007/978-3-030-58861-8_2
10. Campra, P. (2021). Detection of graphene in COVID19 vaccines by Micro-RAMAN spectroscopy. https://www.researchgate.net/publication/355979001_DETECTION_OF_GRAPHENE_IN_COVID19_VACCINES
11. El-Araby, H.A.; Malhat, H.A.; Zainud-Deen, S.H. (2017). Performance of nanoantenna-coupled geometric diode with infrared radiation. En: 2017 34th National Radio Science Conference (NRSC) (pp. 15-21). IEEE. https://doi.org/10.1109/NRSC.2017.7893471| https://sci-hub.mksa.top/10.1109/NRSC.2017.7893471
12. El-Araby, H.A.; Malhat, H.A.; Zainud-Deen, S.H. (2018). Nanoantenna with geometric diode for energy harvesting. Wireless Personal Communications, 99(2), pp. 941-952. https://doi.org/10.1007/s11277-017-5159-2
13. Fahim, H.; Javaid, S.; Li, W.; Mabrouk, I.B.; Al-Hasan, M.; Rasheed, M.B.B. (2020). An efficient routing scheme for intrabody nanonetworks using artificial bee colony algorithm. IEEE Access, 8, pp. 98946-98957. https://doi.org/10.1109/ACCESS.2020.2997635
14. Guo, H.; Johari, P.; Jornet, J.M.; Sun, Z. (2015). Intra-body optical channel modeling for in vivo wireless nanosensor networks. IEEE transactions on nanobioscience, 15(1), pp. 41-52. https://doi.org/10.1109/TNB.2015.2508042
15. Jornet, J.M.; Akyildiz, I.F. (2013). Graphene-based plasmonic nano-antenna for terahertz band communication in nanonetworks. IEEE Journal on selected areas in communications, 31(12), pp. 685-694. https://doi.org/10.1109/JSAC.2013.SUP2.1213001
16. Jornet, J.M.; Akyildiz, I.F. (2014). Femtosecond-long pulse-based modulation for terahertz band communication in nanonetworks. IEEE Transactions on Communications, 62(5), pp. 1742-1754. https://doi.org/10.1109/TCOMM.2014.033014.130403
17. Khan, A.A.; Jayaswal, G.; Gahaffar, F.A.; Shamim, A. (2017). Metal-insulator-metal diodes with sub-nanometre surface roughness for energy-harvesting applications. Microelectronic Engineering, 181, pp. 34-42. https://doi.org/10.1016/j.mee.2017.07.003
18. Malak, D.; Akan, O.B. (2012). Molecular communication nanonetworks inside human body. Nano Communication Networks, 3(1), pp. 19-35. https://doi.org/10.1016/j.nancom.2011.10.002
19. Nafari, M.; Jornet, J.M. (2015). Metallic plasmonic nano-antenna for wireless optical communication in intra-body nanonetworks. En: Proceedings of the 10th EAI International Conference on Body Area Networks (pp. 287-293). https://doi.org/10.4108/eai.28-9-2015.2261410
20. Piro, G.; Boggia, G.; Grieco, L.A. (2015). On the design of an energy-harvesting protocol stack for Body Area Nano-NETworks. Nano Communication Networks, 6(2), pp. 74-84. https://doi.org/10.1016/j.nancom.2014.10.001
21. Reed, J.C.; Zhu, H.; Zhu, A.Y.; Li, C.; Cubukcu, E. (2012). Graphene-enabled silver nanoantenna sensors. Nano letters, 12(8), pp. 4090-4094. https://doi.org/10.1021/nl301555t
22. Rikhtegar, N.; Keshtgary, M. (2013). A brief survey on molecular and electromagnetic communications in nano-networks. International Journal of Computer Applications, 79(3). https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.402.8701&rep=rep1&type=pdf

23. Rong, Z.; Leeson, M.S.; Higgins, M.D.; Lu, Y. (2018). Nano-rectenna powered body-centric nano-networks in the terahertz band. Healthcare technology letters, 5(4), pp. 113-117. http://dx.doi.org/10.1049/htl.2017.0034 | https://www.researchgate.net/publication/322782473_Nano-Rectenna_Powered_Body-Centric_Nanonetworks_in_the_Terahertz_Band | https://sci-hub.mksa.top/10.1049/htl.2017.0034
24. Sharma, A.; Singh, V.; Bougher, T.L.; Cola, B.A. (2015). A carbon nanotube optical rectenna. Nature nanotechnology, 10(12), pp. 1027-1032. https://doi.org/10.1038/nnano.2015.220
25. Sivapriya, S.; Sridharan, D. (2017). Energy Efficient MAC Protocol for Body Centric Nano-Networks (BANNET). ADVANCED COMPUTING (ICoAC 2017), 422. https://www.researchgate.net/profile/H-Mohana/publication/322790171...
26. Suh, Y.H.; Chang, K. (2002). A high-efficiency dual-frequency rectenna for 2.45-and 5.8-GHz wireless power transmission. IEEE Transactions on Microwave Theory and Techniques, 50(7), pp. 1784-1789. https://doi.org/10.1109/TMTT.2002.800430 | https://sci-hub.mksa.top/10.1109/TMTT.2002.800430
27. Varshney, L.R. (2008). Transporting information and energy simultaneously. En: 2008 IEEE international symposium on information theory (pp. 1612-1616). IEEE. https://doi.org/10.1109/ISIT.2008.4595260
28. Yang, K.; Bi, D.; Deng, Y.; Zhang, R.; Rahman, M.M.U.; Ali, N.A.; Alomainy, A. (2020). A comprehensive survey on hybrid communication in context of molecular communication and terahertz communication for body-centric nanonetworks. IEEE Transactions on Molecular, Biological and Multi-Scale Communications, 6(2), pp. 107-133. https://doi.org/10.1109/TMBMC.2020.3017146
29. Yang, K.; Pellegrini, A.; Munoz, M.O.; Brizzi, A.; Alomainy, A.; Hao, Y. (2015). Numerical analysis and characterization of THz propagation channel for body-centric nano-communications. IEEE Transactions on Terahertz Science and technology, 5(3), pp. 419-426. https://doi.org/10.1109/TTHZ.2015.2419823
30. Zainud-Deen, S.H.; Malhat, H.A.; El-Araby, H.A. (2017). Energy harvesting enhancement of nanoantenna coupled to geometrie diode using transmitarray. En: 2017 Japan-Africa Conference on Electronics, Communications and Computers (JAC-ECC) (pp. 152-155). IEEE. https://doi.org/10.1109/JEC-ECC.2017.8305799 | https://sci-hub.mksa.top/10.1109/JEC-ECC.2017.8305799
31. Zhang, R.; Yang, K.; Abbasi, Q.H.; Qaraqe, K.A.; Alomainy, A. (2017). Analytical characterisation of the terahertz in-vivo nano-network in the presence of interference based on TS-OOK communication scheme. IEEE Access, 5, pp. 10172-10181. https://doi.org/10.1109/ACCESS.2017.2713459