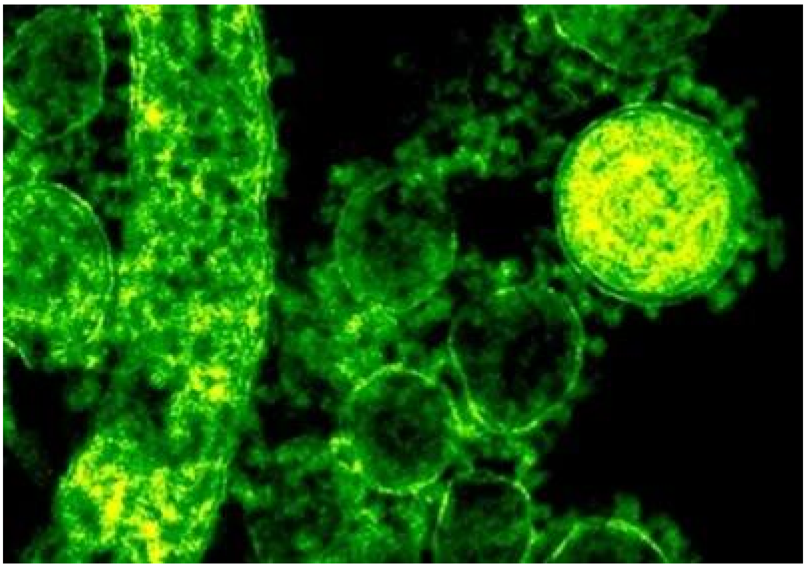
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is an enveloped, positive-sense, single-stranded RNA virus. Its proteome has a total of 29 proteins consisting of 16 nonstructural (NSP), 4 structural proteins (SP), and 9 open reading frames (ORF). Four structural proteins are spike (S), membrane (M), envelope (E), and nucleocapsid (N) proteins. In this article, the authors from Australia used several techniques to investigate the chemical reactivity of SARS-CoV-2 with diverse surfaces of electrodes and the impact of the electric field on the SARS-CoV-2 S protein at the single-molecule level.

The S protein is a glycosylated homotrimer with each monomer composed of subunits S1 and S2. It is responsible for the recognition and binding of the virus to the host cell angiotensin-converting enzyme 2 (ACE2) receptor. It also mediates the SARS-CoV-2 entry into the host cell. The S1 domain comprises an N-terminal domain (NTD), a receptor-binding domain (RBD) with a receptor binding motif (RBM), and two C-terminal domains. The S2 subunit contains the fusion machinery required for viral-cell membrane fusion. SARS-CoV-2 S proteins are proteolytically processed by host pro-protein convertase furin. As a result, S proteins display cleaved forms of S1 and S2 subunits.

The structures of the S proteins of most coronaviruses, including SARS-CoV-2, have multiple disulfide (S-S) bonds. The S1 and S2 subunits contain 14 S–S bonds in well-defined regions. The RBD in the S1 subunit contains four S–S bridges, the NTD contains three S–S bridges and the S1/S2 cleavage site contains three S–S bridges. The abundance of S–S bridges suggests their important structural role in the S protein architecture and stabilization. It is believed that these S–S bonds are essential for the ability of the S protein to infect a host cell through its interaction with the ACE2 receptor.



About the Study and Results

The authors used several techniques, including surface spectroscopy, electrochemical analysis, and scanning tunneling microscopy to investigate the chemical reactivity of SARS-CoV-2 with diverse surfaces of electrodes. They also evaluated the impact of the electric field on the S protein at the single-molecule level.

The results showed that disulfide bonds in the S1 subunit react and form covalent bonds with gold, copper, platinum, and silicon (Si) electrodes and denatures.

In contrast, there was no covalent bonding between the S1 subunit and plastic or stainless steel. The S1 subunit of SARS-CoV-2 S protein was only physically adsorbed on these surfaces. These findings may explain why SARSCoV-2 survives only a limited time on copper, in contrast to its viability on stainless steel or plastics. These results are consistent with a study on the viability of the Delta variant of the SARS-CoV-2, incubated with environmental biofilms from three meat packaging plants, on materials such as stainless steel, PVC, and ceramic tiles. The SARS-CoV-2 Delta variant was detectable and viable on all materials tested.
https://discovermednews.com/sars-cov-2-remained-viable-in-environmental-biofilms-for-five-days-and-increased-their-biovolume/

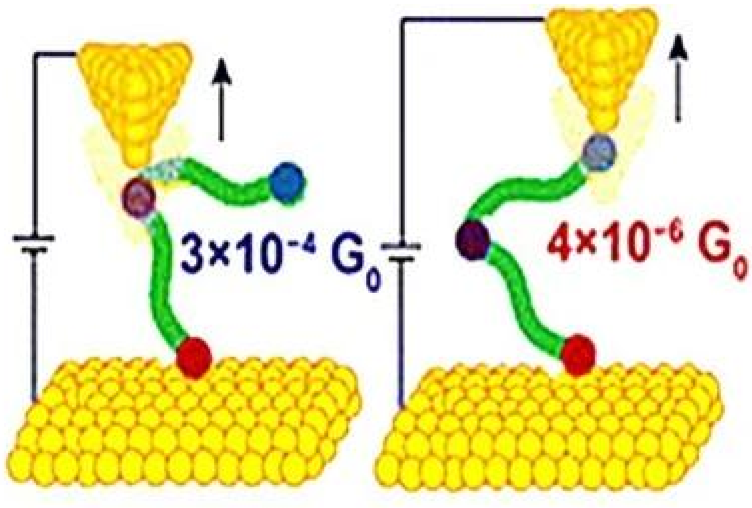


Figure from the original article of Dief EM and

Darwish N, 2023.

The results also showed that the S1 subunit was highly conductive at the single-molecule level. The conductance of a single S1 protein was surprisingly high and ranged between two states of 3×10^{-4}G and 4×10^{-6}G (1G = 77.5 µS). These two conductance states were governed by the reaction of disulfide bonds with Au, which controlled the orientation of the protein in the circuit. Clear conductance signals were observed only in electric fields equal to or lower than 7.5 × 107 V m−1. The original conductance magnitude decreased in an electric field of 1.5 × 108 V m−1. Above an electric field of 3 × 108 V m−1, junctions with the S1 protein were not observed.

The authors attributed the disappearance of the protein's current signature at these field magnitudes to protein denaturation that resulted in the electron channels blocking across the protein and an unfavorable orientation of the S1 protein at high electric fields.

Conclusion

These results revealed that SARS-CoV-2 spike protein is electrically conductive, and reacts with gold, silicon, copper, and platinum electrodes and denatures. In contrast, there was no covalent bonding between the S1 subunit and plastic or stainless steel, and S1 was only physically adsorbed on these surfaces.

These findings may explain why SARSCoV-2 survives only a limited time on copper, in contrast to its viability on stainless steel or plastics.

All future coronaviruses will possess peripheral disulfide bonds in their S proteins, and therefore, the reactions of SARS-CoV-2 disulfide bonds with metals and silicon are of great importance. These findings provide new opportunities for developing coronavirus-capturing materials capable of irreversibly trapping the virus *via* strong covalent bonds, and potentially electrically deactivating persistent and future variants of SARS-CoV-2.

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