Agent 007: Organic Molecules as Bearers of Secrets

KIT Scientists Design Chemical Compounds for Use as Passwords for Encrypted Information – Publication in Nature Communications

Invisible password: The information for encryption is hidden in the molecule, e.g. a liquid droplet on paper. (Photo: Amadeus Bramsiepe, KIT)

In the digital age, security of sensitive information is of utmost importance. Many data are encrypted before they enter the data highway. Mostly, these methods use a password for decryption, and in most cases, exactly this password is the entrance gate for hackers. Scientists of Karlsruhe Institute of Technology (KIT) use a new and highly secure approach by combining computer science with chemistry and a conventional encryption method with a chemical password. Their development is now reported in an open access publication in Nature Communications. (DOI: 10.1038/s41467-018-03784-x)

Today, very good and highly effective encryption programs exist, which are difficult to overcome, provided that the computer capacity is limited. The password, however, always remains the weak point. If it is badly chosen and does not meet the necessary security requirements, it is the Achilles heel of entire encryption. Exactly here is the starting point of work of the scientists of KIT: They conceal the information of the password in a small organic molecule. And while the encrypted digital information can travel publicly, the key to read the

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Additional materials:

Original publication:
https://www.nature.com/articles/s41467-018-03784-x

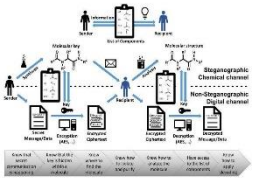
information is transported invisibly and without the knowledge of the environment in a form of a small volume of a chemical compound, e.g. as a droplet on paper.

“Of course, this method is only suited for applications requiring high security levels and, hence, justifying a high expenditure, examples being the transmission of intelligence or communication of embassies,” says Professor Michael Meier of KIT’s Institute of Organic Chemistry. Other applications might be identification or anti counterfeit tags. We can work with smallest amounts and also find them in materials, in which other chemical compounds, such as DNA molecules, cannot be used,” first author Andreas Boukis adds. The scientists succeeded in reliably isolating chemical keys from various carrier materials, such as paper, perfume, instant coffee, green tea, sugar, and even pork blood.

Application of the password in the form of a molecule, sending the message, extracting the molecule, and decryption: The simplified representation above illustrates a highly complex and highly secure method. (Photos: Amadeus Bramsiepe, KIT; graphics: Leon Kühner, KIT)

The information of the chemical key is hidden in the sequence of building blocks and the attached sidechains. Each of these chemical components is assigned a letter and a number. Depending on which components are synthesized in which sequence and with which sidechains, an individual alphanumerical code results for the password molecule. It is read out with a specially developed computer program and converted into a binary code. For synthesis, the scientists used a conventional so-called multi-component reaction. It allows to synthesize a previously defined molecule in one step with a small expenditure. As basic components, the researchers selected suitable commercially available compounds. With this database of 130 different basic compounds, 500,000 chemical keys can be synthesized, containing a basic information of 18 bits each. By combining various chemical keys that can also be transmitted at various times and

places, information storage capacity and, hence, security can be further increased. As the compounds are highly robust, they are suited for a variety of carrier materials. Thanks to another property, they are also easy to find: At a certain position, they have a special sidechain that facilitates recovery, so-called perfluoroalkyls. Their properties are similar to those of teflon, i.e. they do not like to interact with aqueous (polar) or fatty (unpolar) media, but only with other perfluorinated compounds. For this reason, these molecules can be separated selectively from a mixture. The isolated compounds are then analyzed using a conventional highly sensitive analysis method, mass spectrometry. The mass of entire molecules, but also of defined fragments is determined. If the library of the 130 possible initial components is known, conclusions can be drawn with respect to the molecule and the password for decryption can be read out.



Computer science meets chemistry: Encryption and decryption in detail. (Graphics: Andreas Boukis, KIT)

“The idea to send information via secret channels is not new. But our process is characterized by the fact that we provide a highly robust secret channel that needs minimum amounts of the key molecule only,” Professor Dennis Hofheinz of the Institute of Theoretical Informatics summarizes the advantages of chemical passwords.

The new method was developed within the framework of the Collaborative Research Center (CRC) 1176 “Molecular Structuring of Soft Matter” of the German Research Foundation (DFG), which is coordinated by KIT. Nine million euros have been granted for the first four years to the CRC that started in January 2016.

Original Publication:

A. C. Boukis, K. Reiter, M. Frölich, D. Hofheinz, and M. A. R. Meier: Multicomponent reactions provide key molecules for secret communication. Nature Communications, 2018. DOI:10.1038/s41467-018-03784-x.

https://www.nature.com/articles/s41467-018-03784-x

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