Separation of Enantiomers by Their Enantiospecific Interaction with Achiral Magnetic Substrates

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The chemical building blocks of life and many biologically active materials such as drugs and pesticides are molecules that have either right- or left-handed configuration (e.g. enantiomers), a concept referred to as *chirality*. Chiral molecules having the same chemical composition but different 'handedness' may have extremely different biological effects. One infamous example is the drug thalidomide, which was marketed in racemic form, as a mixture of its two enantiomers; one had the desired therapeutic effect while the other caused severe birth defects. Other drugs, such as Ritalin and Cipramil, are also marketed in their premium enantiomerically pure forms (Focalin and Cipralex, respectively) that are more potent and have fewer side effects. Therefore, the regulatory trends in the pharmaceutical industry incentivize the marketing of enantiomerically pure materials. For example, today only 13% of chiral drugs are marketed as single stereoisomers, although FDA regulatory recommendations are to achieve separation in all drugs. Another driver for the development of enantiomerically pure materials is the extension of patent protection.

A decade of research collaboration between Professor Ron Naaman at the Weizmann Institute (Israel) and Professor Yossi Paltiel at the Hebrew University (Israel) led to results recently published in *Science* that show chiral-selective affinity of molecules to magnetic surfaces. Professor Naaman said: "Using this technology, one enantiomer adsorbs preferentially on perpendicularly magnetized substrates when the magnetic dipole is pointing up, whereas the other adsorbs faster for the opposite alignment of the magnetization. The interaction is not controlled by the magnetic field *per se*, but rather by the electron spin orientations."

Proof-of-concept work presented in the *Science* paper showed that it is possible to achieve preferential adsorption on achiral materials, such as thin films, of a number of chiral compounds – including peptides, DNA and small molecules – by applying opposite magnetic dipoles.

Professor Naaman concluded: "This work leads to a breakthrough column and crystallization technology providing for the first time a generic technique for chiral separation. The technique is simple and cost-effective and does not have to be customized for each specific material."

An animation explaining this work is available at the link: https://vimeo.com/257954972

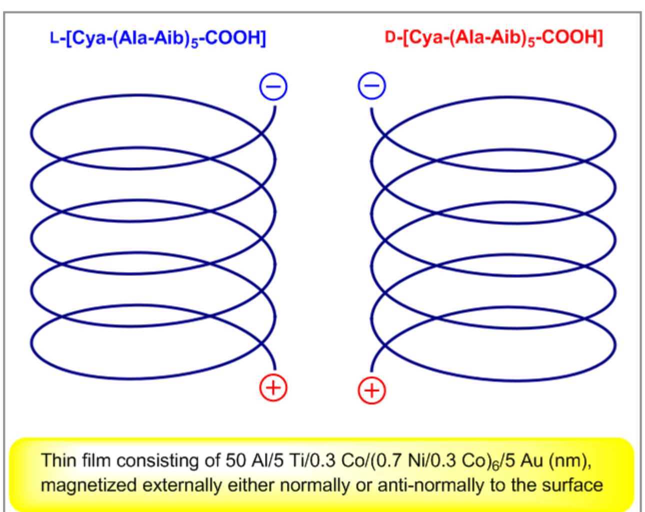

Figure 1 One of the applications of the new technology: enantioselective adsorption of peptides on the Au of a thin film coating a flow column as a result of opposite magnetizations

About the authors

Professor Y. Paltiel

Yossi Paltiel, born in 1968, is now in the Applied Physics Department in the Hebrew University of Jerusalem (Israel). Professor Paltiel has worked both for leading high-tech industry groups and in the academic world. He has been leading the Quantum Nano Engineering group at the Hebrew University, Israel since July 2009. The goal of Professor Paltiel's group is to establish a way to incorporate quantum mechanics into room-temperature 'classical' computation and reading schemes mimicking biological and chemical processes. Professor Paltiel has published more than 110 papers in leading journals and issued 13 patents. He has a startup company named Valentis Nanotech, founded in 2013. The company utilizes nanocellulose's unique properties to produce a biodegradable transparent sheet with additional controlled optical and gas/water barrier properties.

Professor R. Naaman

Ron Naaman completed his B.Sc. in chemistry at the Ben Gurion University, Beer-Sheva, Israel, and his Ph.D. at the Weizmann Institute in Israel. He then moved for a postdoctoral fellowship to Stanford, California (USA) for two years and then spent one year at the Chemistry Department at Harvard (USA). In 1980, he returned to Israel and became a faculty member at the Weizmann Institute. Since 1992 he has been a full professor in the Department of Chemical Physics at the Institute. His research group discovered the chirality-induced spin-selectivity effect, the result of which is spin-selective electron transport through chiral molecules.