understanding and application of such spin phenomena is a promising future direction for organic semiconductors. ❐

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Jan Behrends[1], Ifor D. W. Samuel[2], Alexander Schnegg[3] and David J. Keeble[4]*
[1]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany, [2]Organic Semiconductor Centre, SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews KY16 9SS, UK, [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Institute Silicon Photovoltaics, Kekuléstraβe 5, D-12489 Berlin, Germany, [4]SUPA, Division of Physics, University of Dundee, Dundee DD1 4HN, UK.
*e-mail: d.j.keeble@dundee.ac.uk

More than spectroscopy

To the Editor — While we appreciate the attempt by Boehme and Lupton to outline several failures of research efforts in organic spintronics[1], on some issues we have different opinions and judgements.

Boehme and Lupton criticize conclusions on spin-related phenomena in organic semiconductors based on magnetoresistance measurements, which are linked to the reversal of the electrodes' magnetization. Indeed, there are still many unsolved puzzles in the results provided by this approach. For example, in the prototypical vertical device composed of a $La_{0.7}Sr_{0.3}MnO_3$/tris(8-hydroxyquinolinato)aluminium(Alq3)/Co multilayer, spintronic effects are detectable in a voltage range from 1–10 mV to 1 V (ref. 2), whereas for Alq3 the injection barriers to the lowest unoccupied molecular orbital or the highest occupied molecular orbital conducting levels is about 1–2 eV (ref. 3). This demonstrates the need to consider intragap states (or possibly a band) caused by either defects or impurities, but a fully fledged debate on this topic has not started yet. Another example is the very origin of the magnetoresistance, which is neither clearly formalized nor understood yet. The absence of the Hanle effect further complicates matters. In inorganic spintronics the Hanle effect had the role of ultimate proof of spin injection in the spin-transporting medium[4]. Unexpectedly, the absence of the Hanle effect was firmly established in devices involving several organic materials[5,6]. Thus, a lively debate on this topic has spread within the community and a number of scientists are at work to reveal the new physics at the basis of this and other unusual observations in organic spintronics. Along this track Zigang Yu[7] has recently advanced the hypothesis of charge–spin separation in organic conducting media, which implies the absence of the Hanle effect in some conduction regimes and gives a theoretical justification to the presence of magnetoresistance.

Transport investigations have also revealed other unforeseen properties such as easy tuning and control of magnetoresistance by the application of a voltage[8], suggesting new device concepts such as the magnetically modulated memristor. Besides fundamental interest, focus on magnetoresistance is justified by the fact that most of the foreseeable applications are based on it or on variations thereof. From this point of view, Boehme and Lupton listed several shortcomings that organic semiconductors have in comparison with inorganic spin-transporting media; we would like to strike one out. The spin–lattice relaxation time T_1 is about 1 ns in Si (ref. 9), whereas it is of the order of 1 μs for organic semiconductors[10]. This contradicts the statement that, in organic semiconductors, T_1 too falls short of the performance of inorganic spin-transporting media.

Summarizing, we definitely support the call by Boehme and Lupton for more spectroscopic studies. Optical, X-ray and tunnelling spectroscopies have already been intensively employed to reveal strong and captivating spin-filtering effects at organic/ferromagnetic interfaces[11,12], not in contrast with but greatly enhancing the understanding of spin-transport results[13]. To make further and decisive steps towards understanding of spin-related effects in organic semiconductors the community needs perhaps to strengthen all its tools, including spectroscopic and transport studies, and try to increase the efforts in achieving the highest possible overlap between them. Studying spin behaviour inside organic materials by spectroscopy does not solve the question of whether organic spintronics will be limited to the manipulation of spin species intrinsic to the material, or will be able to exploit spin injection and transport, so as to work far beyond the equilibrium regime. ❐

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V. Alek Dediu* and Alberto Riminucci
ISMN-CNR, Bologna, Italy.
*e-mail: V.Dediu@bo.ismn.cnr.it

Standardization should come first

To the Editor — We agree with Boehme and Lupton[1] that the organic spintronics community should focus more on scrutinizing the existing models and to carry out detailed spectroscopic experiments. However, there are other elements to take into consideration. In addition to distinguishing whether the bipolaron model or polaron-pair model applies when interpreting the magnetotransport properties of organic materials, another important task is to identify the contributions of the factors that cause spin relaxation, that is, the hyperfine field and spin–orbit coupling. The hyperfine field is considered the dominant factor, due to the lack of heavy atoms and the presence of hydrogen in organic