

Photochemionic Devices

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In the last few years there has been a great interest in developing electronics at a molecular level (molecular electronics), e.g. to construct miniaturized electric circuits that would be much smaller than the corresponding micron-scale digital logic circuits fabricated on conventional solid-state semiconductor chips. An alternative way towards information processing at the molecular level is combination of photonics and chemionics. Suitably designed supramolecular species are indeed capable of combining light and chemical inputs to perform functions that mimic those of macroscopic devices. This paper describes the working principles of molecular-level photochemionic devices for (i) chemical switching of photonic input/output signals, (ii) chemical tuning of photonic input/output signals, (iii) chemical and photonic switching of optical properties, and (iv) light powered, chemical input(s), optical output logic gates.

Keywords: *Photonics, chemionics, molecular devices, fluorescence*

Introduction

The miniaturization of components for the construction of useful devices is currently pursued by the top-down approach. This approach, which is in the hands of physicists and engineers, consists in manipulating progressively smaller pieces of matter by photolithography and related techniques. It is becoming clear, however, that the top-down approach is subjected to drastic limitations for dimensions smaller than 100 nanometers.¹

An alternative strategy towards technology at the nanometer scale is offered by the bottom-up approach. Chemists are in an ideal position to develop bottom-up strategies for the construction of nanoscale devices since they are able to manipulate molecules, the smallest entities of matter with distinct shapes and properties. In fact, the molecule-by-molecule bottom-up strategy is nothing else than supramolecular chemistry, a discipline extensively developed in recent years.²

In the last few years there has been a great interest in developing electronics at a molecular level (molecular electronics), e.g. to construct miniaturized electric circuits that would be much smaller than the corresponding micron-scale digital logic circuits fabricated on conventional solid-state semiconductor chips.³ With this aim, a great number of investigations on electrical conductivity and electrical switching properties of molecules and supramolecular systems have been performed.⁴ A schematic diagram for an AND logic gate based upon diodes and its proposed molecular implementation is shown in Figure 1.⁵ Such a gate would measure only about $3 \text{ nm} \times 4 \text{ nm}$, which means one million times smaller in area than the corresponding logic element fabricated on a semiconductor chip using transistor-based circuits. OR and XOR gates and a half adder of this type have also been designed. However, much remains to be learned about the mechanisms of conductance of molecular wires and switches, as well as about the means of manipulating, bonding, and ordering

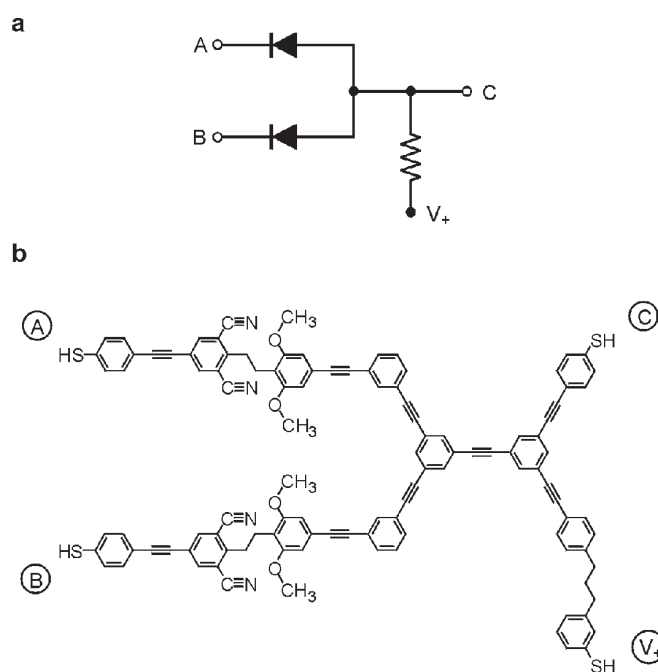


Fig. 1 – Electronic circuit scheme (a) and proposed molecular implementation (b) of a diode-diode AND logic gate⁵

Slika 1 – Shema električnog kruga (a), predložena molekularna primjena (b), dioda-dioda AND logičkog sklopa⁵

them in extended circuit-like structures. If this approach is successful, it will be possible to construct ultrahigh-density molecular circuitry that would have great impact in computer science (a Pentium on a pinhead).⁵

It can be expected, however, that the bottom-up approach will move science and technology not only from micro- to nano-scale, but also from electronics to photonics and chemionics since light and chemical inputs are convenient ways to power molecular-level devices and to exchange information at the molecular level. Furthermore, the bot-

tom-up approach, taking inspiration from natural nanoscale devices, could displace the interest of scientists from solid state to solution and soft-matter. In the next few years, the bottom-up approach is likely to lead to a wealth of nanodevices in which photonics and chemionics will be integrated in order to obtain specific functions.

Up until now scarce attention has been devoted to the possibility of developing photonics at the molecular level because selective excitation of a specific molecule in a supramolecular array is prevented by diffraction-limited spot size considerations. However, progress in near-field optical techniques⁶ and electromagnetic energy transport in metal nanoparticle plasmon waveguides⁷ seems to overcome this difficulty.

Regardless of the possibility of short-term applications, the development of a set of components for information processing by molecular photochemionics appears to be a worthwhile investment.⁸ In this paper we will review some recent achievements in this field, namely: (i) chemical switching of photonic input/output signals; (ii) chemical tuning of photonic input/output signals; (iii) chemical and photonic switching of optical properties; (iv) light powered, chemical input(s), optical output logic gates.

Chemical switching of photonic input/output signals: a molecular plug/socket system

Supramolecular species whose components are connected by means of non-covalent forces can be disassembled and re-assembled⁹ by modulating the interactions that keep the components together, thereby allowing switching of energy- or electron-transfer processes. Two-component systems of this type are reminiscent of plug/socket electrical devices and, like their macroscopic counterparts, must be characterised by (i) the possibility of connecting/disconnecting the two components in a reversible way, and (ii) the occurrence of an electron or electronic energy flow from the socket to the plug when the two components are connected (Figure 2a). Hydrogen-bonding interactions between ammonium ions and crown ethers are particularly convenient for constructing molecular-level plug/socket devices since they can be switched on and off quickly and reversibly by means of acid-base inputs.

A plug/socket system which deals with the transfer of electronic energy is illustrated in Figure 2b.¹⁰ The absorption and fluorescence spectra of a CH_2Cl_2 solution containing equal amounts of (\pm)-binaphthocrown ether **1** and amine **2** indicate the absence of any interaction between the two

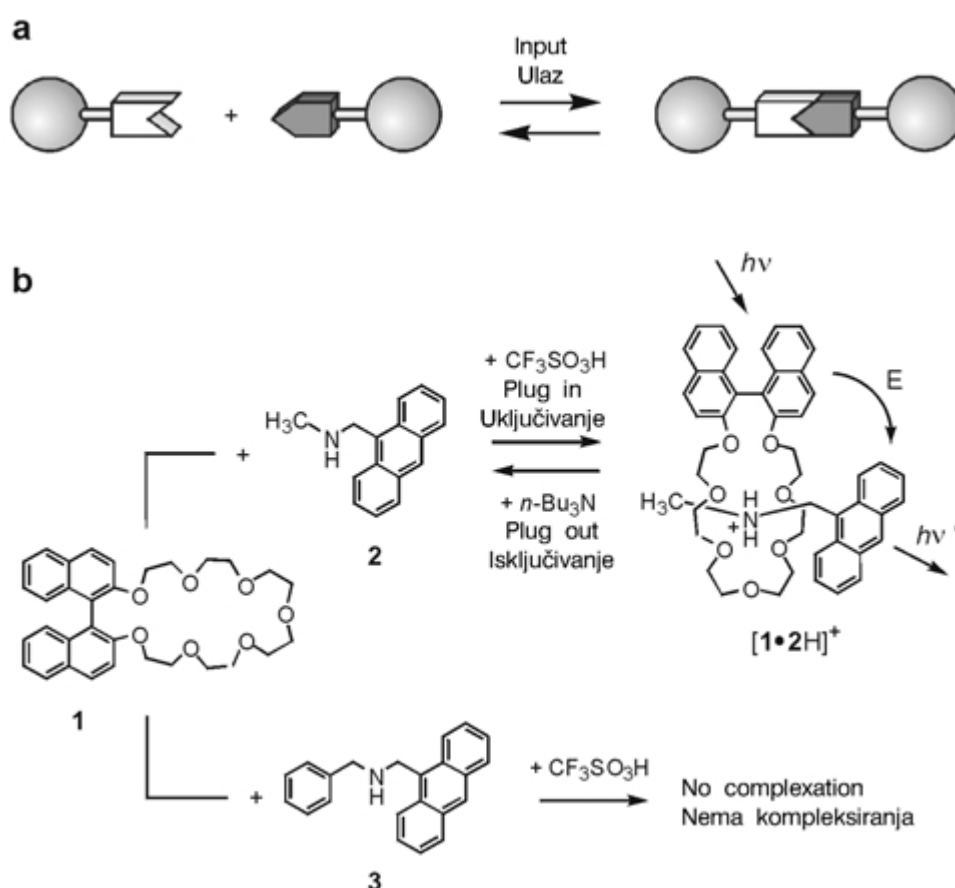


Fig. 2 – A molecular-level plug-socket system for energy transfer based on the reversible acid-base driven threading-dethreading motions in the hydrogen bonded pseudorotaxane $[\mathbf{1} \cdot \mathbf{2H}]^+$ (CH_2Cl_2 , 298 K). The acid-driven threading of compound **3**, incorporating a bulky benzyl group, through the macrocyclic cavity of **1**, does not occur.¹⁰

Slika 2 – Sustav utičnice za prijenos energije na molekularnom nivou utemeljen na reverzibilnim kiselo-baznim promjenama vezivanja i otpuštanja u pseudorotaksanu vezanom vodikovom vezom $[\mathbf{1} \cdot \mathbf{2H}]^+$ (CH_2Cl_2 , 298 K). Kod spoja **3**, koji ima veliku benzilnu skupinu, ne dolazi do povezivanja kroz makrocikličku šupljinu spoja **1** niti uz pomoć kiseline.¹⁰

compounds. Addition of a stoichiometric amount of acid causes profound changes in the fluorescence behaviour of the solution, namely (i) the fluorescence of **1** is quenched, and (ii) the fluorescence of $[2H]^+$ is sensitized upon excitation with light absorbed exclusively by the crown ether. These observations are consistent with the formation of a pseudorotaxane-type adduct wherein very efficient energy transfer takes place from the binaphthyl unit of the crown ether to the anthracenyl group incorporated within the dialkylammonium ion. Such a pseudorotaxane can be disassembled by the subsequent addition of a stoichiometric amount of base, thereby interrupting the photoinduced energy flow, as indicated by the fact that the initial absorption and fluorescence spectra are restored. Interestingly, the plug-in process does not take place when a plug component incompatible with the size of the socket, such as the benzyl-substituted amine **3**, is employed (Figure 2b).

Chemical tuning of the output-to-input signal conversion

As we have seen above, in suitably designed A–B supramolecular systems, light excitation of component A can be followed by energy transfer to component B which can thus emit light. In such systems the input light signal is con-

verted into an output signal of different wavelength, characteristic of the B species. In the case in which A is a receptor capable of hosting a variety of luminescent B species (B_1, B_2, \dots), it happens that the same light input on A can be converted into output light signals of predetermined wavelengths, depending on the specific B_n species that is hosted into A. Chemical tuning of the output-to-input signal conversion can thus be achieved in these systems.

A luminescent dendrimer hosting luminescent metal ions

Dendrimer **4** (Figure 3) contains in the interior 18 amide groups, which are known to strongly coordinate lanthanide ions, and in the periphery 24 chromophoric dansyl units which show intense absorption bands in the near UV spectral region and an intense fluorescence band in the visible region. We have investigated¹¹ the complexation of dendrimer **4** by six lanthanide ions ($Gd^{3+}, Tb^{3+}, Yb^{3+}, Nd^{3+}, Eu^{3+}, Er^{3+}$) characterized by very different energy-level patterns (Figure 4a) and capable of exhibiting their own luminescence. Among these ions, Eu^{3+} and Yb^{3+} are rather easy to reduce ($E^\circ = -0.35$ and -1.1 V, respectively, vs standard hydrogen electrode, in aqueous solution), whereas none of them can be easily oxidized.

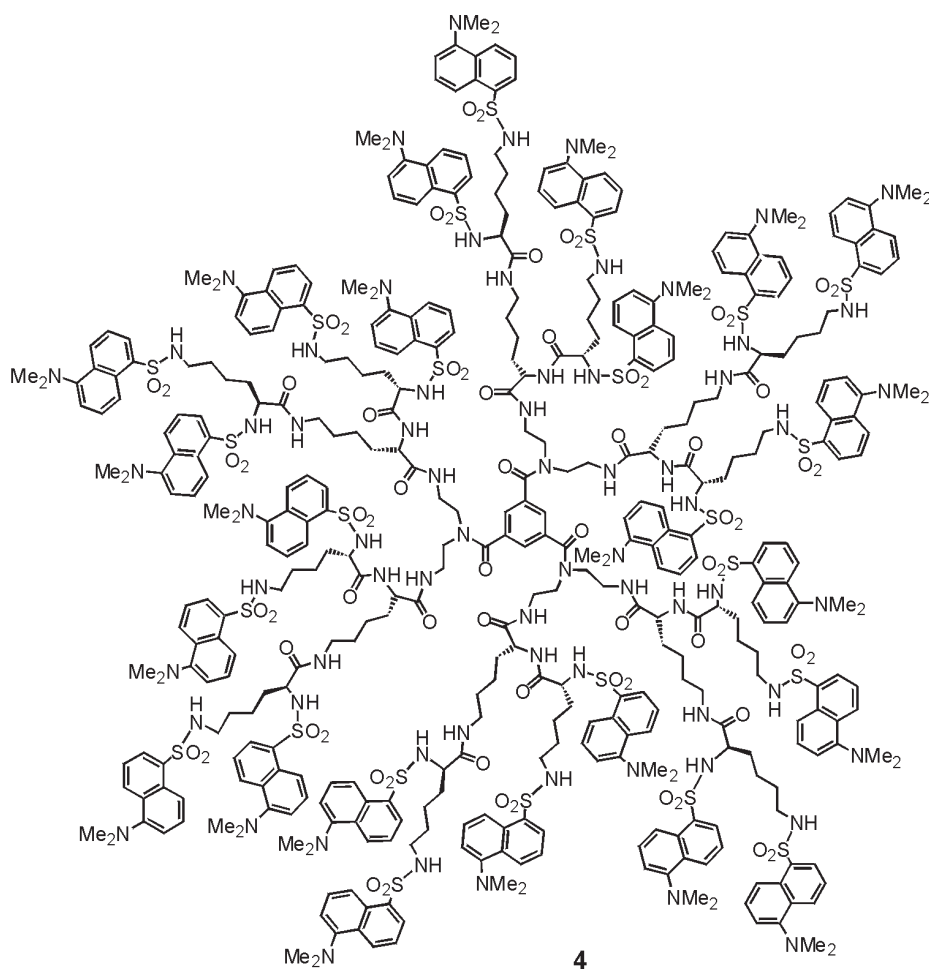


Fig. 3 – Structure formula of the polylysine dendrimer **4** functionalised at the periphery with 24 dansyl units

Slika 3 – Strukturna formula polilizinskog dendrimera **4** funkcionaliziranog na krajevima s 24 dansilne jedinice

Formation of the metal complexes $[\text{Ln}^{3+}\mathbf{C4}]$ is accompanied by a quenching of the fluorescent excited state of the dansyl units. The quenching effect is very large for Nd^{3+} and Eu^{3+} , moderate for Er^{3+} and Yb^{3+} , small for Tb^{3+} , and very small for Gd^{3+} . In the present context, the most relevant results are those obtained with Nd^{3+} , Er^{3+} and Yb^{3+} (Figure 4b).

For $[\text{Nd}^{3+}\mathbf{C4}]$ and $[\text{Er}^{3+}\mathbf{C4}]$, quenching by electron transfer of the dansyl fluorescence is thermodynamically forbidden. The observed quenching effect is accompanied by the sensitised near infrared (NIR) emission of the $^4\text{F}_{3/2}$ ($\lambda_{\text{max}} = 1066 \text{ nm}$) and $^4\text{I}_{13/2}$ ($\lambda_{\text{max}} = 1525 \text{ nm}$) excited state of Nd^{3+} and Er^{3+} , respectively. Energy transfer by a Förster-type mechanism is more efficient in the case of Nd^{3+} because of the more extensive overlap between the dansyl emission band and the energy levels of the metal ion.

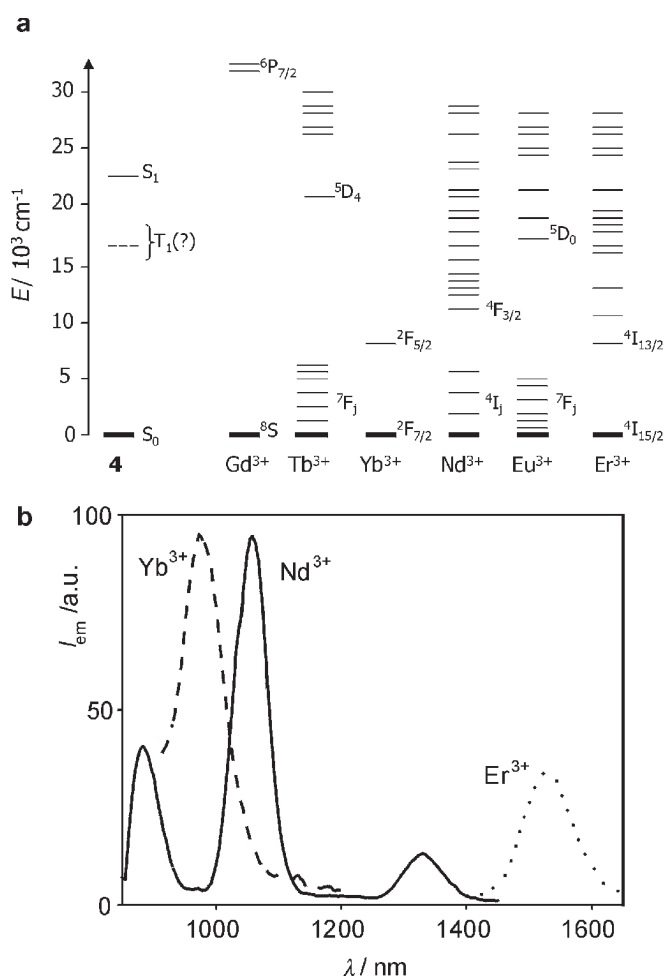


Fig. 4 – (a) Energy-level diagrams for the dansyl units of dendrimer **4** and the investigated lanthanide ions. The position of the triplet excited state (T_1) of **4** is uncertain because no phosphorescence can be observed.¹¹ (b) Sensitized NIR emission of Nd^{3+} (full line), Er^{3+} (dotted line), and Yb^{3+} (dashed line) ions in a 5:1 acetonitrile/dichloromethane solution containing $8.0 \times 10^{-6} \text{ mol L}^{-1}$ **4** and $2.4 \times 10^{-5} \text{ mol L}^{-1}$ metal ions. $\lambda_{\text{exc}} = 343 \text{ nm}$.¹¹

Slika 4 – Dijagrami energetske nivoa za dansilne jedinice dendrimera **4** i istraživanih iona lantanida. Pozicija pobuđenog tripletnog stanja (T_1) spoja **4** neodređena je jer se ne može opaziti fosforescencija.¹¹ (b) Senzitivirana NIR emisija iona Nd^{3+} (puna linija), Er^{3+} (točkasta linija) i Yb^{3+} (isprekidana linija) u acetonitril/diklorometanskoj otopini 5:1 koja sadrži $8,0 \times 10^{-6} \text{ M}$ spoja **4** i $2,4 \times 10^{-5} \text{ M}$ metalnih iona. $\lambda_{\text{exc}} = 343 \text{ nm}$.¹¹

The case of $[\text{Yb}^{3+}\mathbf{C4}]$ is very interesting. A moderate quenching effect is accompanied by the sensitised emission of the $^2\text{F}_{5/2}$ Yb^{3+} level (Figure 4b). The interpretation of this result is not straightforward. In fact, whereas the moderate quenching ability on the dansyl fluorescence could be assigned to an electron-transfer quenching mechanism, which is thermodynamically allowed, the sensitisation of the $^2\text{F}_{5/2}$ emission is an unexpected result since energy transfer from the S_1 excited state of the dansyl unit appears to be unlikely because of the lack of spectral overlap. It should be noted, however, that for $[\text{Yb}^{3+}\mathbf{C4}]$, the $[\text{Yb}^{2+}\mathbf{C4}^+]$ electron transfer level lies above the luminescent metal-centered level. Therefore, quenching by electron transfer can be followed by a back electron transfer leading to the formation of the lower lying, luminescent $^2\text{F}_{5/2}$ level rather than the $^2\text{F}_{7/2}$ ground state. In rigid matrix at 77 K, i.e. under conditions in which the $[\text{Yb}^{2+}\mathbf{C4}^+]$ electron transfer level moves to much higher energy, the sensitised emission of the $^2\text{F}_{7/2}$ Yb^{3+} level can no longer be observed, confirming that the low energy $^2\text{F}_{5/2}$ level cannot be populated by direct energy transfer from the S_1 excited state of the dansyl unit.

In conclusion, the incident UV light input is converted into a NIR output, fine tuned by the nature of the coordinated metal ion.

Luminescent dendrimers hosting luminescent dyes

Dendrimer **5** (Figure 5) consists of a hexamine core surrounded by 8 dansyl-, 24 dimethoxybenzene-, and 32 naphthalene-type units.¹² In dichloromethane solution, **5** exhibits the characteristic absorption bands of the component

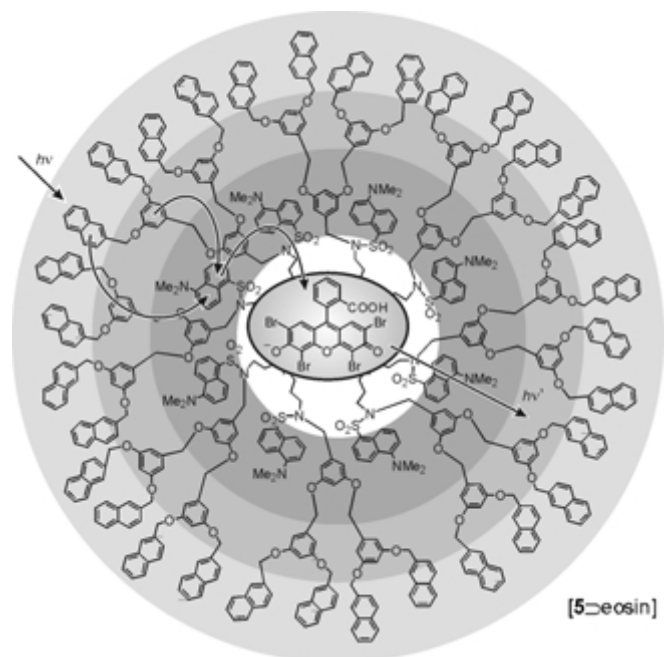


Fig. 5 – Schematic representation of the energy-transfer processes taking place in dendrimer **5**, which contains three different types of light-harvesting chromophoric units and a hosted eosin molecule.¹²

Slika 5 – Shematski prikaz procesa prijenosa energije koji se događaju u dendrimeru **5** koji sadrži tri različite vrste kromofornih jedinica za skupljanje svjetla te molekulu eosina kao domaćina.¹²

units and a strong dansyl-type fluorescence. Energy transfer from the peripheral dimethoxybenzene and naphthalene units to the fluorescent dansyl units occur with > 90 % efficiency. When the dendrimer hosts a molecule of the fluorescent eosin dye (eosinC5), the dansyl fluorescence, in its turn, is quenched and sensitisation of the fluorescence of the eosin guest can be observed. Quantitative measurements showed that the encapsulated eosin molecule collects electronic energy from all the 64 chromophoric units of the dendrimer with an efficiency > 80 %. Both intramolecular (i.e., within dendrimer) and intermolecular (i.e., dendrimer host \rightarrow eosin guest) energy-transfer processes occur very efficiently by a Förster type mechanism because of the strong overlap between the emission and absorption spectra of the relevant donor/acceptor units.

In this system, UV input signals are converted into visible output signals. By using different dyes, a fine tuning of the visible output signal can be achieved.

Chemical and photonic switching of optical properties

Most photochromic compounds¹³ change their colour by photoexcitation and revert more or less slowly to their initial state when kept in the dark (Figure 6a). Compounds exhibiting this behaviour (classified as T-type) are useless for information storage (or switching purposes) since the written information (switching state) is spontaneously erased (back converted) after a relatively short time. Other photochromic compounds do not return to the initial state thermally, but can undergo reversible photoconversion (Figure 6b). Such compounds (classified as P-type) present a severe problem. The light used for reading the written data (i.e., for detecting the switching state) causes the back-conversion of the sampled molecules and therefore the gradual loss of information (state definition). Several attempts have been made to overcome this difficulty, including the use of photochemically inactive infrared light to read the status of the system.

A general approach to avoid destructive reading is to combine two reversible processes that can be addressed by means of two different stimuli (dual-mode systems). In such systems (Figure 6c), light is used to convert A to B (write), then a second stimulus I(2) (e.g., a proton, an electron, etc.) is employed to transform B (which would be reconverted back to A by a direct photon reading process) into C, another stable state of the system (lock), that can be optically detected without being destroyed (read). Through this process, the change caused by the writing photon is safeguarded. When the written information has to be erased, C is reconverted back to B by a stimulus opposite to I(2) (unlock; e.g., by a base, a hole, etc.), and B is then reconverted back to A (erase). Such a write-lock-read-unlock-erase cycle can constitute the basis for optical memory systems with multiple storage and non destructive readout capacity.

A write-lock-read-unlock-erase system

Several systems have recently been reported to perform a write-lock-read-unlock-erase cycle. An example is offered by the flavylium compounds.¹⁴ In aqueous solutions the compounds of this family undergo various structural tran-

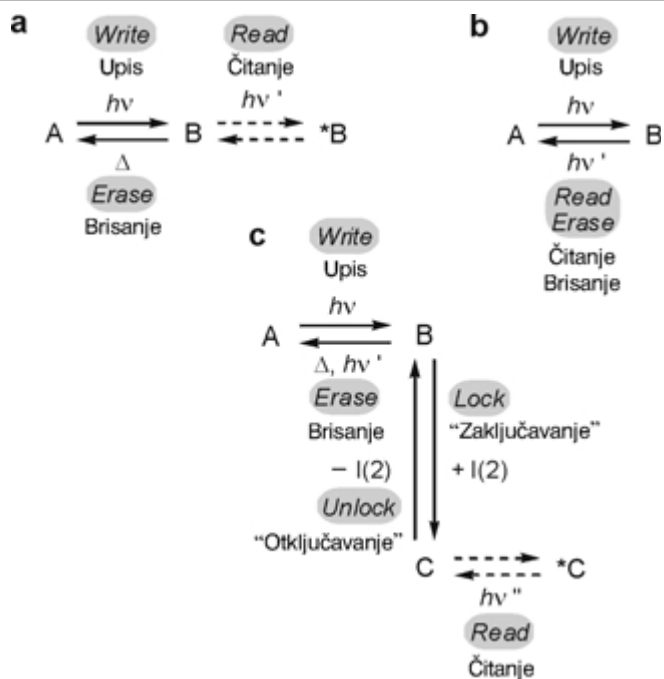


Fig. 6 – Schematic representation of the behaviour of three types of photochromic systems. (a) The photochemical reaction of the form A is thermally reverted in the dark. (b) The photochemical reaction of the form A is reverted thermally or by light excitation of the form B. (c) The form B, which goes back to A under light excitation, can be transformed by a second stimulus I(2) into another form C which is stable toward light excitation and, when necessary, can be reconverted to B.

Slika 6 – Shematski prikaz ponašanja tri tipa fotokromatskih sustava. (a) Fotokemijska reakcija forme A termički je povratna u mraku. (b) Fotokemijska reakcija forme A povratna je svjetlosnim pobuđivanjem forme B. (c) Forma B, koja se zbog svjetlosnog pobuđenja vraća natrag u formu A, može se transformirati pomoću sekundarnog podraživača I(2) u formu C, koja je stabilna pod svjetlosnim pobuđenjem, ali se, po potrebi, može ponovno vratiti u formu B.

sformations that can be driven by light excitation and pH changes (Figure 7a), and are often accompanied by quite dramatic colour changes. The **Ct** and **Cc** forms are the *trans* (more stable) and *cis* (less stable) isomers of the chalcone species, **AH⁺** is the flavylium cation (which becomes the most stable species in strongly acid solution), and **B2** is a hemiacetal species in fast equilibrium with **Cc** (for the sake of simplicity, in the following **B2** + **Cc** will be simply indicated by **Cc**). The write-lock-read-unlock-erase cycle of the 4'-methoxyflavylium ion in aqueous solution can be described making reference to Figure 7b, with **Ct**, **Cc**, and **AH⁺** playing the role of the species A, B, and C of Figure 6c: (i) the stable form **Ct** can be photochemically converted by irradiation with 365 nm light (write) into the **Cc** form that can be reconverted back either thermally or on optical reading; (ii) by a second stimulus (addition of acid, which can also be present from the beginning without perturbing the behaviour of the system, pH \leq 3.0), **Cc** can be converted into the kinetically inert form **AH⁺** (lock); (iii) the **AH⁺** form shows a spectrum clearly distinct from that of **Ct** and is photochemically inactive, so that it can be optically detected (read) without being erased; (iv) by addition of base, **AH⁺** can be reconverted into **Cc** (unlock); (v) **Cc** can be thermally or photochemically reconverted into the initial **Ct** form (erase). It should be noted that the loc-

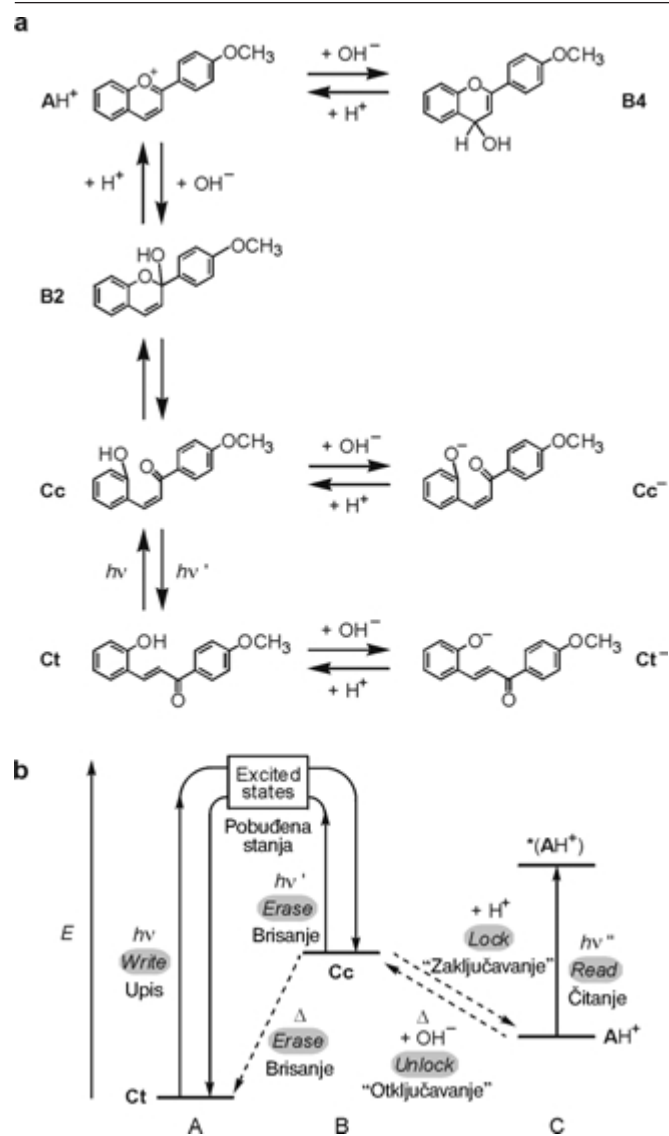


Fig. 7 – (a) Light and pH driven interconversions among the various forms of 4-methoxyflavylium. (b) Schematised representation of the write-lock-read-unlock-erase cycle of the 4-methoxyflavylium ion¹⁴

Slika 7 – (a) Interkonverzije različitih oblika 4'-metoksiflavilija uzrokovane svjetlom i promjenom pH. (b) Shematski prikaz ciklusa piši-zaključaj-čitaj-otključaj-obriši 4'-metoksiflavilijevog iona¹⁴

king time of the written information bit is not indefinite (at 25 °C and pH 3.0, the half-life of the back reaction from AH⁺ to Ct is ≈ 8 days).

Light powered, chemical input(s), optical output logic gates

In a solid-state transistor the current flowing from a source to a drain can be modulated by a gate potential. It is possible to design molecular-level photochemionic systems which work on a similar principle, except that the source is a light energy input, the drain is a light energy output (luminescence), and the gate is a chemical input (Figure 8). This happens, for example, in the systems in which the luminescence signal can be quenched by photoinduced electron-transfer (PET) processes, as schematically illustra-

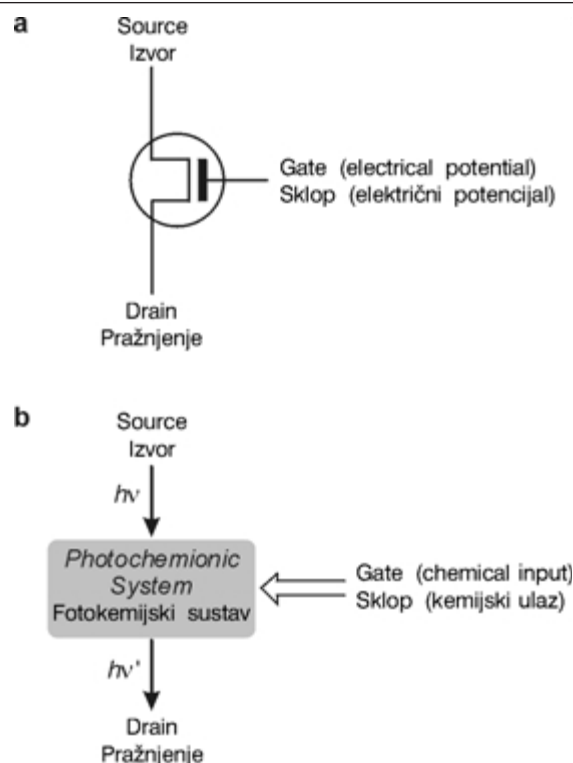


Fig. 8 – Schematic illustration of the similarity between a MOSFET electronic transistor (a) and a photochemionic gate (b)

Slika 8 – Shematski prikaz sličnosti između MOSFET elektroničkog tranzistora (a) i fotokemijskog sklopa (b)

ted in Figure 9.¹⁵ In this figure, F is a potentially fluorescent unit (e.g., an anthracene molecule), whose fluorescent excited state is quenched by PET from the HOMO orbital of an appended electron donor receptor, D (e.g., an amine unit). When the HOMO orbital of the electron donor is engaged by a suitable added molecule or ion (in the case of an amine, e.g., by protonation), fluorescence can be observed, because the HOMO of the donor is lowered in energy and electron transfer can no longer occur.

These systems combine photonics with chemionics and therefore their working principles are closer to those that govern the processes of information transfer in living organisms, rather than to those exploited in artificial solid state devices.

For the sake of space, we will only illustrate two examples of light powered, chemical input(s), optical output logic gates. An exhaustive discussion is given in chapter 9 of ref. 8.

An AND logic gate

The AND operator has two inputs and one output (Figure 10a) and in a simple electrical scheme it can be represented by two switches in series. Figure 10b illustrates the case of an anthracene derivative that produces a virtually perfect truth table.¹⁶ In methanol, the fluorescence quantum yield in the presence of 10⁻³ mol L⁻¹ H⁺ and 10⁻² mol L⁻¹ Na⁺ is 0.22 (output state 1, fourth line of the truth table, Figure 10c), whereas none of the three output states 0 has quantum yield higher than 0.009. The PET quenching process involves the amine moiety in the first two states of the

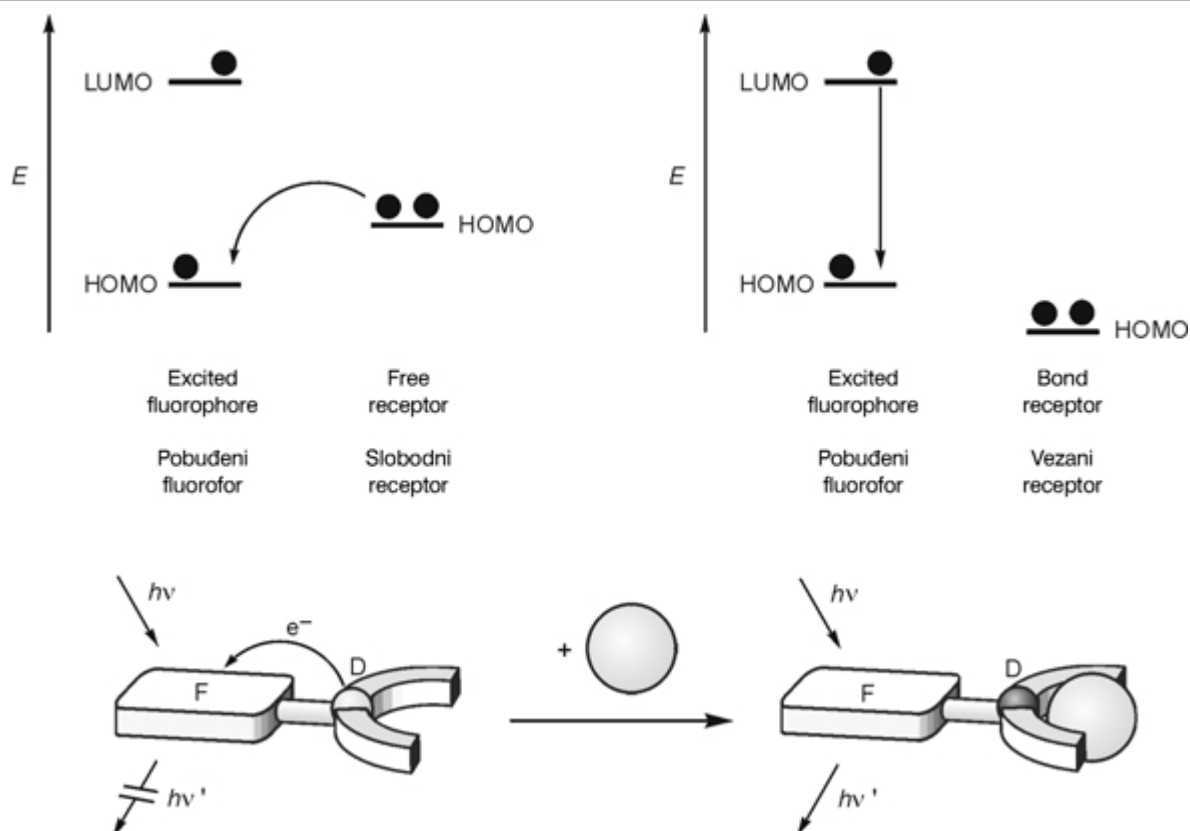


Fig. 9 – Schematic illustration of fluorescence switching by photoinduced electron transfer (PET)
Slika 9 – Shematski prikaz promjene fluorescencije prijenosom fotoinduciranih elektrona (PET)

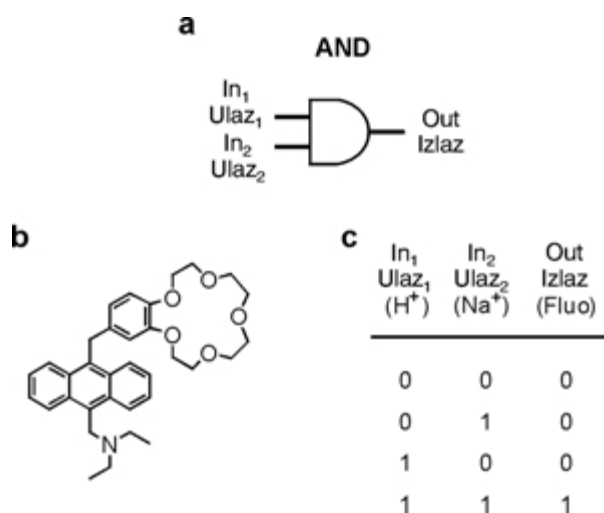


Fig. 10 – Symbolic representation (a), molecular implementation (b), and truth table (c) of an AND logic gate based on a three-component system¹⁶

Slika 10 – Simbolički prikaz (a), molekularne uporabe (b), i stvarna tablica (c), AND logičkih sklopova utemeljenih na sustavu s tri komponente¹⁶

truth table and, of course, the crown ether in the third one. Interestingly, the crown ether alone would not be able to quench the anthracene fluorescence, but when the amine is protonated the process becomes thermodynamically allowed and it does occur.

It can be noted that the AND molecular-level logic gates shown in Figures 1 and 10 are completely different, not

only for the chemical structure of the molecules on which they are based, but also for the chemical environment (solid state and solution, respectively) and the input and output signals. They are, in fact, different from a philosophical viewpoint: whereas the AND gate of Figure 1, is a device for solid-state electronics, that of Figure 10, as well as related system like the XOR gate described below, work on chemical principles that are more similar to those ruling information transfer in living organisms.

A XOR logic gate

The eXclusive OR (XOR) logic gate is particularly important because it can compare the digital state of two signals. If they are different an output 1 is given, whereas if they are the same the output is 0. This logic operation has proven to be difficult to emulate at the molecular scale, but some examples are now available.^{17,18,19}

A light powered, chemical input(s), optical output XOR logic gate is illustrated in Figures 11 and 12.¹⁷ The electron-rich macrocycle **6** can be threaded by an electron-deficient wire-type molecule like **7**²⁺. The resulting pseudorotaxane [**6**·**7**]²⁺ is held together by charge transfer (CT) interactions. Assembling is signalled by as many as three different optical channels: (i) appearance of a red colour because of the presence of a CT absorption band in the visible region; (ii) disappearance of the blue-green fluorescence of **7**²⁺, and (iii) disappearance of the UV fluorescence of **6** with $\lambda_{\max} = 343$ nm (the disappearance of the two fluorescent signals is due to the presence of the lower lying CT state in the complex). For the XOR function, protons and

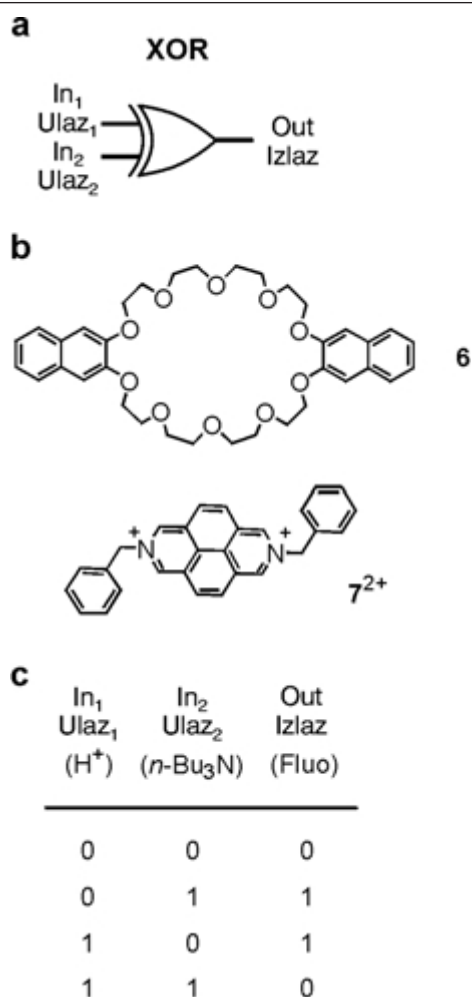


Fig. 11 – Symbolic representation (a), molecular implementation (b), and truth table (c) of a XOR logic gate.¹⁷ The working mechanism of the system is fully illustrated in Figure 12.

Slika 11 – Simbolički prikaz (a), molekularna uporaba (b), i stvarna tablica (c) XOR logičkih sklopova.¹⁷ Mehanizam rada sustava u potpunosti je ilustriran na slici 12.

n-Bu₃N are the inputs and the fluorescence of **6** at 343 nm is the output. The working mechanism of this system is illustrated schematically in Figure 12.¹⁷ As mentioned above, in the absence of the two inputs the fluorescence of **6** is quenched in the pseudorotaxane (output 0). When the Bu₃N input alone is applied, the pseudorotaxane dethreads because of the formation of a stronger CT interaction between the amine and **7**²⁺. Under such conditions, **6** is free and its fluorescence is not quenched (amine input 1, output 1). Application of the H⁺ input causes protonation of **6** and, again, dethreading of the pseudorotaxane. Since protonation of **6** (presumably at the aliphatic ether oxygens) does not perturb its emission compared to the neutral form, the H⁺ input 1 causes an output 1. Therefore the output achieves logic state 1 in the two situations in which *exclusively* one of the two inputs is present. However, when both inputs are applied in stoichiometric amounts, acid-base neutralisation results, the pseudorotaxane remains intact and the 343 nm emission is quenched (output 0).

Conclusions

In this perspective article, we have shown that molecular level systems can be designed to obtain (i) chemical switching of photonic input/output signals, (ii) chemical tuning of photonic input/output signals, (iii) chemical and photonic switching of optical properties, and (iv) light powered, chemical input(s), optical output logic operations.

The molecular electronic approach, in which molecules are used as simple circuit components, exemplified by the AND gate shown in Figure 1, has the potential advantage of being strictly related to the paradigms of current microelectronics technology.²⁰ On the other hand, the “photochemionic” approach illustrated by the systems described above, can lead to a better understanding of natural information processing systems and can perhaps lead to a new “soft” technology.

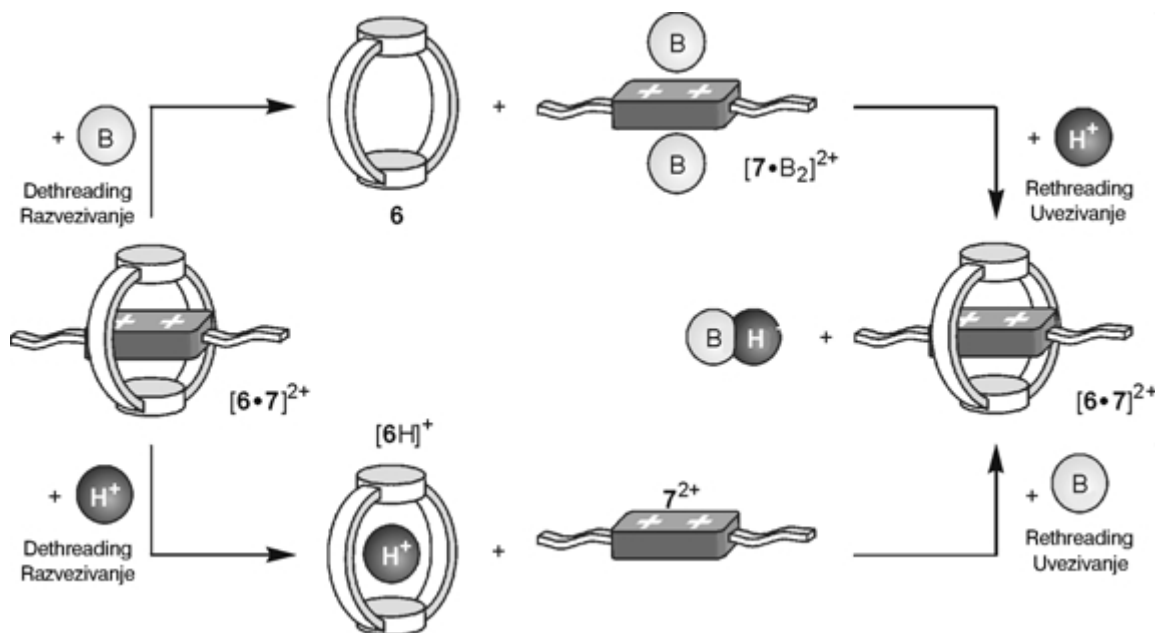


Fig. 12 – Working mechanism of the XOR logic gate based on the compounds shown in Figure 11b¹⁷
Slika 12 – Mehanizam rada XOR logičkog sklopa utemeljen na spojevima prikazanim na slici 11b¹⁷

Regardless of the possibility of short-term applications, the development of a set of components for information processing by molecular photochemionics seems a worthwhile investment.⁸

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SAŽETAK

Fotokemijske naprave

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U posljednjih nekoliko godina pojavio se velik interes za razvojem elektronike na molekularnoj razini (molekularne elektronike), na primjer za konstruiranje minijaturiziranih električnih krugova koji bi bili znatno manji od svojih odgovarajućih mikronskih digitalnih logičkih krugova proizvedenih na konvencionalnim poluvodičkim čipovima u čvrstom stanju. Alternativni način za procesuiranje informacija na molekularnoj razini bio bi kombiniranje fotonike i kemionike. Prikladno dizajnirane supramolekularne vrste zaista su sposobne spojiti svjetlosne i kemijske informacije za izvedbu funkcija koje oponašaju funkcije makroskopskih naprava. Ovaj rad opisuje načela rada fotokemijskih naprava na molekularnoj razini za (i) kemijsko mijenjanje fotonskih primljenih/odaslanih signala, (ii) kemijsko podešavanje fotonskih primljenih/odaslanih signala, (iii) kemijsko i fotonsko mijenjanje optičkih karakteristika te (iv) logičkog sklopa na bazi svjetlosnog pogona s kemijskim ulaznim te optičkim izlaznim signalima.