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THE ROLE OF DIELECTROPHORESIS IN THE DETECTION AND SEPARATION OF CIRCULATING TUMOR CELLS

BY

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Abstract. Dielectrophoresis (DEP) is a method of manipulating, including separating, of target object (nano and/or microparticles, living cells) in the presence of a non-uniform electric field. In recent years, the method has found numerous applications in the bio-medical fields, especially in oncology, more precisely in the study of circulating tumor cells (CTCs). CTCs are cells released by a tumor during its early stages of metastasis, when secondary tumors cannot yet be detected by classical imaging methods. Thus, DEP may be a useful adjuvant method in the earlier detection of cancer. In this context, this article offers a new perspective on a topic of great interest nowadays. Presenting in the first two parts in detail the technique of DEP and the most important physical-biological characteristics of the CTCs, the article lists in the final part the most relevant and recent applications of this technique in the field of tumor cells, opening possible future research directions.

Keywords: Circulating tumour cells; lab-on-chip device; dual frequency dielectrophoresis; traveling wave dielectrophoresis.

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1. Introduction

Circulating tumour cells (CTCs), initially observed and described in 1869 by Thomas Ashworth in a patient with metastatic cancer, have returned to the attention of oncology researchers over the past decade. There is still an exuberance in terms of the great potential this type of cells may have in the early diagnosis of cancer. Moreover, they play also an important role in the evaluation of the tumour response to treatment, offering a powerful prognostic tool for medium and long term survival (Tan and Wu, 2018). To date, the prognostic role of CTCs in various cancers (breast, prostate, and lung cancers) has been clearly demonstrated, but the ability to diagnose a tumour as early as possible based on the detection of CTCs in peripheral blood remains a challenge (Vasseur *et al*., 2021).

Known as liquid biopsy, the technique involves collecting a peripheral blood sample, a non-invasive technique compared to classical biopsy, in which a fragment of tissue / organ is obtained. Although it has many advantages for the patient, in the case of the desire to detect CTCs, this technique is imperfect, requiring improvements. The major problem with CTCs is their low concentration in peripheral blood (below 5 CTCs per mL), infinitely lower compared to red blood cells or even lymphocytes normally present in a blood sample. Thus, no matter how representative CTCs may be in characterizing a tumor, it is mandatory to improve the detection technique by increasing its sensitivity and specificity. In this context, dielectrophoresis (DEP) may be a simple but effective way to better separate CTCs from other cells of a liquid biopsy. This paper aims to analyse in detail the role that DEP plays in the detection of living cells from a heterogeneous cell mixture, focusing on the detection of CTCs from a blood sample, addressing this issue in three parts. Initially, the authors explain the technical-mathematical bases of the method, then the characteristics of CTCs are detailed, which can be both advantages and limitations in terms of their detection, and finally, the most relevant results obtained in recent years in this field are presented, with future research directions also being suggested.

2. Dielectrophoresis

Dielectrophoresis (DEP) is the phenomenon of the movement of dielectric polarized material in a fluid under the action of a non-uniform electric fields. This electrokinetic process was first described by Pohl in the early 1950s, being mainly observed in alternative current. In the presence of a non-uniform electric field gradient, the object will be moved towards or outwards of the field, and its permittivity will be greater or less than the permittivity of the suspension fluid. It is called positive DEP phenomenon if the target object is

pulled towards the region of the stronger field and negative DEP effect when the particular is rejected by the field.

One of the advantages of using DEP in particle handling is the fact that the target particle is not necessary to be electrically charged. In the presence of a non-uniform electric field gradient, the particle will act as an electric dipole, a phenomenon characterized by an induced dipole moment. Thus, when applying an external electric field, the positive and negative charges within the neutral particle from an electrical point of view will be separated and oriented in the field plane, and subsequently the particular will be mobilized (Turcan and Olariu, 2020).

DEP depends on many characteristics, from the dielectric properties of the particles to the properties that characterize the suspension medium (environmental polarizability) or characteristics related to the performance of the measuring / separation device, mainly the Maxwell - Wagner (MW) polarization or the mechanism of interfacial polarization. When we talk about biological elements such as living cells, they have a complex behaviour in the electric field, their response depending on multiple cellular factors such as: physical characteristics of membranes, electrical properties of the cytoplasm, cell size, and extracellular factors such as conductivity of the suspension buffer. From a mathematical point of view, we quantify DEP by the size of F_{DEP}, this force depending on numerous variables, according to Eq. (1):

$$\langle \vec{F}_{DEP} \rangle = 2\pi R^3 \varepsilon_m Re\left[\tilde{f}_{CM}\right] \nabla \left|\vec{E}_{rms}\right|^2 \quad (1)$$

where R is the cell radius, ε_m is the absolute permittivity of the environment, $\vec{E}_{rms}$ is the square-average value of the applied electric field and $Re\left[\tilde{f}_{CM}\right]$ is the real part of the Clausius-Mossotti (CM) factor.

The CM factor refers to the dielectric constant (relative permittivity) of a material, its calculation being made according to the CM relation (Eq. (2)). According to this equation, equivalent to the Lorentz - Lorenz equation, a material can be characterized according to the atomic polarizability, α, of the atoms and / or constituent molecules of the material, or of a homogeneous mixture thereof.

$$\tilde{f}_{CM}(\omega) = \frac{\tilde{\varepsilon}_c - \tilde{\varepsilon}_m}{\tilde{\varepsilon}_c + 2\tilde{\varepsilon}_m} \quad (2)$$

where $\tilde{\varepsilon}_c$ and $\tilde{\varepsilon}_m$ represent the complex relative permittivity of the biological cell and of the environment, respectively, depending on the radian frequency (ω), described by $\tilde{\varepsilon} = \varepsilon - j\sigma / \omega$.

The real part of the CM factor is determined according to the Eq. (3):

$$Re\left[\tilde{f}_{CM}\right] = \left(\frac{\varepsilon_c - \varepsilon_m}{\varepsilon_c + 2\varepsilon_m}\right) + \frac{\left(\frac{\sigma_c - \sigma_m}{\sigma_c + 2\sigma_m}\right) - \left(\frac{\varepsilon_c - \varepsilon_m}{\varepsilon_c + 2\varepsilon_m}\right)}{1 + \omega^2 \tau_{MW}^2} \quad (3)$$

This factor depends on the frequency of the applied field.

Thus, at low frequencies, the cell is less polarizable compared to the suspension buffer, producing the phenomenon of negative dielectrophoresis (nDEP), the cell being rejected from regions with high electric field gradient. By increasing the frequency, when the MW reverse time of the membrane-environment interface is exceeded, the cell membrane becomes essentially 'invisible' to the applied electric field. If the cell is more polarizable than the suspension medium, the dipoles will change direction and the cell will undergo positive dielectrophoresis (pDEP). However, if the frequency is further increased to a value exceeding the MW inverse time scale of the membrane cytoplasm interface, the effective net dipole will depend on the difference in permittivity between the cell interior and the suspension medium. If the permittivity of the solution is higher than the permittivity of the cytoplasm, the dipole will be reversed, and the cell will experience negative F_{DEP}. Thus, within a wide frequency band, there are two moments in which the cell experiences crossover frequencies. First, at lower frequencies, when the phenomenon is dependent on the suspension medium and the properties of the cell membrane, and at high frequencies, when it is dependent on the environment and the cytoplasm of the cell. Recent experiments show that these crossover frequencies would be different depending on the cell type (Pethig, 2017).

3. Circulating Tumor Cells - Focus on Detection Methods

A simplistic definition shows that CTCs are cells released from the primary tumor through the process of metastasis, a process that begins with the epithelial-mesenchymal transition (TEM) stage of primary cancer cells. CTCs begin to flow into the bloodstream at a rate of about 106 cells per gram of tumor.

In the blood, they are found in very small numbers, below 10 cells / mL (sometimes less than 1 cell / mL), which turns them into "rare cells". Although TEM is essential for many normal developmental processes, including mesoderm formation, neural tube formation, or wound healing, the process is also the first step in initiating metastases in cancer progression.

Given the rarity of these cells, it has so far remained difficult to isolate them from the blood and, in addition, having a high heterogeneity, not all the structural, electrical and molecular characteristics of CTCs are yet known. Currently, it is known that CTCs measure 20-30 micrometers in diameter (there are variations, according to the literature, between 9 and 39 micrometers), being larger than capillary pores (8 micrometers) (Diamantopoulou *et al*., 2020). However, CTCs are elastic and manage to travel through capillaries. The nucleus / cytoplasmic ratio is higher than in leukocytes. Recently, an observational study strongly suggests that nucleus size (CTC with very small / small / large nucleus) has been correlated with the stage of the disease in

prostate cancer (Park *et al*., 2014). In particular, the detection of very small nucleus CTCs has been correlated with the presence of visceral metastases in prostate cancer patients. Moreover, there is evidence that the total net load of cancer cells is significantly higher than that of blood cells (Ahmad *et al*., 2018).

Depending on the type of cancer, the stage of the disease, as well as the therapeutic approaches, composition and biological characteristics of the CTCs subpopulations found in liquid biopsies may vary. Moreover, it has been shown that (some) CTCs have a high volume of stem cell markers on their surface, these CTCs being more likely to cause metastases. On the surface of CTCs there may be encountered the following "stem cell" type markers: EpCAM, ALDH1, CD133, CD44, CD24, BMI1.

ALDH1 is a classic stem cell marker that is commonly found on CTCs in breast, pancreatic and lung cancer; CD133 is found on CTC especially in treatment-resistant breast cancer; EpCAM is used in cell enrichment detection methods (de Wit *et al*., 2018).

Given the physical-chemical characteristics mentioned above, it is observed that the detection of these cells in a sample of only a few milliliters of blood can be extremely difficult. Several factors prevent the acquisition of CTCs in sufficient quantities for further research: the rarity of cells in the peripheral circulation (despite the fact that CTCs are released daily in large quantities from the primary tumor, they are found in low concentrations in the peripheral blood), the absence of a specific marker on the surface of CTCs, incomplete molecular and genomic characterization.

One explanation would be that CTCs circulate surrounded / covered by platelet aggregates or coagulation factors and therefore cannot be easily detected through immunological methods (antibodies). Detection itself is a challenge, requiring sensitive and specific methods. To date, many methods for detecting CTCs have been tried, such as immunocytochemistry, fiber optic scanning, polymerase reverse transcriptase chain reaction (RT-PCR), immune-magnetic separation, microchips, etc. Of these, only the CellSearch system has been approved by the FDA since 2004 for the detection of CTCs in breast, prostate and colon cancer, but has not been introduced in clinical practice.

Using the CellSearch System (the current standard for CTC detection), at least ten CTCs in 7.5 mL of blood were detected in only 11% of metastatic colorectal cancer, 32% of metastatic breast cancer, and 40% of cancer cases. of metastatic prostate (Swennenhuis *et al*., 2016). To improve detectability, various cell enrichment techniques can be tried to obtain a sample with an increased concentration of CTCs. Most commonly used are surface markers, to which antibodies will be specifically bound, which in turn can be immuno-, fluoro- or radiolabeled. The big disadvantage of the method is that CTCs do not have specific markers on their surface, they depend on the type of tumor (breast, prostate, colon), or can be found on the surface of other blood cells, such as leukocyte precursors.

There is a clear need to improve these methods of detecting CTCs, and the use of DEP as a single method or in combination with other detection and cell separation methods could be the missing key factor.

4. Utility of Dielectrophoresis in CTCs Separation

As separation and study at single-cell level is highly necessary in many applications, researchers have had to find various cell sorting methods. Among the most relevant and utilized in daily practice, we mention: deformability-based separations, inertial-based separations, acoustophoresis, optical tweezers and DEP, with only the last two being capable of sorting and isolating cells. Table 1 summarizes the advantages of DEP over the other handling methods of living cells.

Table 1
Comparison of Different Cell Separation Methods

Detection method	Advantages	Limitations
Deformability-based separation	• High detection sensitivity at low parasitemia • Passive operating principle	• Clogging • Low throughput • Requires additional pre-processing steps
Inertial-based separation	• High-throughput • Effective for rare cell separation	• Sample dilution is required • Insufficient theoretical and practical studies • Needs integration with other microfluidics
Acoustophoresis	• Label free • Mostly gentle on cells	• Similar density and compressibility in most of cell types
Optical tweezers	• Single cell manipulation without mechanical contact • Application of forces of order of piconewtons	• Necessity of high power lasers • Expensive optical setups
DEP	• **Label free** • **Easy incorporable into devices** • **No mechanical contact**	• **Underexplored opportunities in biological materials**

It is known that DEP has found numerous applications in the study and handling of organic (proteins, exosomes, different types of cells) and inorganic components (nano- and micron-sized particles) (Sarno *et al*., 2021). From experiments conducted on inorganic substances, the evaluation of new structures such as carbon nanotubes and other composites (Hamciuc *et al*., 2021), DEP is currently increasingly used in the study of biological cells (Henslee, 2020).

Thus, a first study is the one conducted by Fabbri *et al*., 2013, where researchers used a DEP-based method to characterize CTCs from a metastatic colon cancer, with emphasis on KRAS gene expression as a possible additional tumor characterization factor. The method was also successfully applied in the case of CTCs generated from other tumors. As evidenced in the experiment conducted by Chiriac *et al*., 2020, in which CTCs from a breast cancer cell line (MDA-MB-231) were successfully separated from a peripheral blood sample, using a microfluidic device.

In an effort to increase the sensitivity of capture and separation of CTCs, engineers have found various ways to improve microfluidic devices, from simple to very complex architectural changes. There are numerous examples in the literature, further in Table 2 being highlighted the most relevant types of lab-on-chip devices that could be used with high performance results also in CTCs handling.

Table 2
Most Recent and Relevant Studies on Living Cells where DEP is Successfully Used

Electrochemical principles	Practical use	Reference
Novel zigzag microchannel fluidic device + COMSOL multiphysics software package for fine adjustments	Platelet separation	Guan *et al*., 2020
Tunnel-DEP technology (3D tunnel shape microchannels)	Ultra-high precision size-based cell separation	Kung *et al*., 2021
Association of F_{DEP}, hydrodynamic force and gravitational force	Separation of particles (including living cells) – theoretical model	Lee *et al*., 2012
Association of F_{DEP} and hydrodynamic force in order to separate cells by their size	Separation of red and white blood cells form platelets	Piacentini *et al*., 2011
Applied phase shifts at 90° at the level of parallel electrodes	Separation of Jurkat cells and *Lactobacillus casei*	Van den Driesche *et al*., 2012
Dual frequency DEP	Separation of HEK293 cells and polystyrene beads	Wang *et al*., 2009
Four-branch microfluidic device	Size-based separation of blood cells	Zahedi Siani *et al*., 2020

A first example is the chip built by (Piacentini *et al*., 2011), in which the association between F_{DEP} and hydrodynamic force is used to separate particles (blood cells) depending on their size. The cellular elements of the blood enter the microchannel from one side (the left side). Large red blood cells and white blood cells are pushed under F_{DEP} to the right of the channel and collected at the exit, while the much smaller platelets will be diverted to the left due to the fact that F_{DEP} is not strong enough to affect them. Through this procedure, a very efficient separation of blood cells is achieved, with important biomedical applications.

Another high-performance cell sorting device was developed by (Lee *et al*., 2012) being based on the resulting force of the association between hydrodynamic force, gravity and F_{DEP}. Based on gravity, the chip does not need an external pump to regulate the fluid flow. After focusing the sample, it enters the separation channel. Here, the fluid enters under the action of F_{DEP} whose direction is perpendicular to the plane of the electrode and oriented upwards, and under the action of the composite force of gravity and hydrodynamic force, which is directed downwards at a certain angle. A resultant force will be created based on the value of the aforementioned forces. Thus, if the F_{DEP} is not strong enough, the resulting force will be directed downwards, and if the F_{DEP} exceeds the gravitational and hydrodynamic forces, the resulting force will be ascending. When the resulting force is directed downwards, the particle will fall below the plane of the electrode, achieving their separation. This method has a good degree of specificity, the engineer having full control and the possibility to adjust the particle sorting according to the absolute value of the F_{DEP}.

Kung *et al*., 2021 have redesigned the microfluidic chip to a 3D tunnel shape, creating an ultra-high precision size-based cell separation platform which uses tunnel-DEP technology. Significant structural changes of the microchip architecture were explored in another study, where linear channels were transformed in zigzag-shaped microchannels. Advantages of this new structure comparative to classical ones was the reduction in the required horizontal distance needed for separation and the creation of an asymmetric DEP electric field, facilitating separation of platelets (Guan *et al*., 2020). Sometimes however, simpler designs may be also effective, such as the four-branch microfluidic device used to separate blood cells in four different categories (platelets, red blood cells, neutrophils, and large lymphocytes) upon their size (Zahedi Siani *et al*., 2020).

Improvement of particle separation can be obtained also by modifying the dielectrophoresis technique, two new methods being worth mentioning: traveling-wave dielectrophoresis and dual frequency dielectrophoresis.

Progressive wave DEP can be generated by applying phased currents on parallel electrodes, such as in the work conducted by Van den Driesche *et al*., 2012. Under the action of FDEP, the particle will move along or against the direction of field movement, depending on the imaginary part of the Clausius -

Mossotti factor. Therefore, different particles can be separated based on the difference between the imaginary parts of the CM factor.

To illustrate the practical utility of dual frequency dielectrophoresis, the particle separation chip developed by (Wang *et al*., 2009) is a good example. The device has interdigitated electrodes embedded on both sides of the channel. By applying signals of different frequencies and sizes to the set of electrodes (the frequencies and voltages applied to the electrodes on the left are 8 V, 10 MHz, and on the right are 10 V, 50 kHz), various particles can achieve dielectric equilibrium in different positions, being then transported towards the channels exit under the action of hydrodynamic force, thus performing the sorting. Although both HEK293 cells and polystyrene beads face the action of F_{DEP}, due to the difference in dielectric properties, the beads are pushed to the left and the cells are pushed to the right of the channel, being collected separately.

5. Conclusion

DEP, having significant advantages comparative to other physical techniques used in separating biological particles, remains an important and useful resource for cell separation and manipulation. However, at present, with still many unknowns related to CTCs, researchers have difficulties finding an optimal method for detecting and separating these cell types from peripheral blood samples. However, it remains certain that DEP can be at least an adjuvant method to increase the chance of detecting these rare cells when collecting biological samples via non-invasive manoeuvres such as liquid biopsy.

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REFERENCES

Ahmad M.A., Natour Z.A., Mustafa F., Rizvi T.A., *Electrical Characterization of Normal and Cancer Cells*, IEEE Access 2018, 6, 25979-25986, doi: 10.1109/ACCESS.2018.2830883.

Chiriac E., Avram M., Bălan C., *Dielectrophoretic Separation of Circulating Tumor Cells and Red Blood Cells in a Microfluidic Device*, 2020 International Semiconductor Conference (CAS), 2020, pp. 211-214, doi: 10.1109/CAS50358.2020.9267984.

de Wit S., Zeune L.L., Hiltermann T.J.N., Groen H.J.M., Dalum G.V., Terstappen L.W.M.M., *Classification of Cells in CTC-Enriched Samples by Advanced Image Analysis*, Cancers (Basel), 2018, 10(10), 377, doi:10.3390/cancers10100377.

Diamantopoulou Z., Castro-Giner F., Aceto N., *Circulating Tumor Cells: Ready for Translation?* J. Exp. Med., 2020 Aug 3, 217(8), e20200356, doi: 10.1084/jem.20200356.

Fabbri F., Carloni S., Zoli W., Ulivi P., Gallerani G., Fici P., Chiadini E., Passardi A., Frassineti G.L., Ragazzini A., Amadori D., *Detection and Recovery of Circulating Colon Cancer Cells Using a Dielectrophoresis-Based Device: KRAS Mutation Status in Pure CTCs*, Cancer Lett. 2013 Jul 10, 335(1), 225-231, doi: 10.1016/j.canlet.2013.02.015.

Guan Y., Liu Y., Lei H., Liu S., Xu F., Meng X., Bai M., Wang X., Yang G., *Dielectrophoresis Separation of Platelets Using a Novel Zigzag Microchannel. Micromachines* (*Basel*), 2020 Sep 25, 11(10), 890, doi: 10.3390/mi11100890.

Hamciuc C., Asandulesa M., Hamciuc E., Roman T., Olariu M.A., Pui A., *Novel Polyimide/Copper-Nickel Ferrite Composites with Tunable Magnetic and Dielectric Properties*, Polymers, 2021, 13(10), 1646, https://doi.org/10.3390/polym13101646.

Henslee E.A., *Review: Dielectrophoresis in Cell Characterization. Electrophoresis*, 2020 Nov, 41(21-22), 1915-1930, doi: 10.1002/elps.202000034.

Kung Y.C., Niazi K.R., Chiou P.Y., *Tunnel Dielectrophoresis for Ultra-High Precision Size-Based Cell Separation*, Lab Chip. 2021 Mar 21, 21(6), 1049-1060, doi: 10.1039/d0lc00853b.

Lee J., Kim Y., Beebe D.J., Kim B., *Harnessing Gravitational, Hydrodynamic and Negative Dielectrophoretic Forces for Higher Throughput Cell Sorting*, BioChip J., 6, 229-239 (2012).

Park S., Ang R.R., Duffy S.P., Bazov J., Chi K.N., Black P.C., Ma H., *Morphological Differences Between Circulating Tumor Cells from Prostate Cancer Patients and Cultured Prostate Cancer Cells*, PLoS One. 2014 Jan 8, 9(1), e85264, doi: 10.1371/journal.pone.0085264.

Pethig R., *Dielectrophoresis: Theory, Methodology, and Biological Applications*, John Wiley & Sons, Ltd., 2017.

Piacentini N., Mernier G., Tornay R., Renaud P., *Separation of Platelets from Other Blood Cells in Continuous-Flow by Dielectrophoresis Field-Flow-Fractionation*, Biomicrofluidics, 2011, 5(3), 34122-341228, doi:10.1063/1.3640045.

Sarno B., Heineck D., Heller M.J., Ibsen S.D., *Dielectrophoresis: Developments and Applications from 2010 to 2020*, Electrophoresis. 2021 Mar, 42(5), 539-564, doi: 10.1002/elps.202000156.

Swennenhuis J.F., van Dalum G., Zeune L.L., Terstappen L.W., *Improving the CellSearch® System*, Expert Rev Mol Diagn. 2016 Dec, 16(12), 1291-1305, doi: 10.1080/14737159.2016.1255144.

Tan Y., Wu H., *The Significant Prognostic Value of Circulating Tumor Cells in Colorectal Cancer: A Systematic Review and Meta-Analysis*, Curr Probl Cancer, 2018 Jan-Feb, 42(1), 95-106, doi: 10.1016/j.currproblcancer.2017.11.002.

Turcan I., Olariu M.A., *Dielectrophoretic Manipulation of Cancer Cells and Their Electrical Characterization*, ACS Comb Sci. 2020 Nov 9, 22(11), 554-578, doi: 10.1021/acscombsci.0c00109.

Van den Driesche S., Rao V., Puchberger-Enengl D., Witarski W., Vellekoop M.J., *Continuous Cell from Cell Separation by Traveling Wave Dielectrophoresis*, Sens. Actuators B. 170, 207-214 (2012).

Vasseur A., Kiavue N., Bidard F.C., Pierga J.Y., Cabel L., *Clinical Utility of Circulating Tumor Cells: An Update*, Mol Oncol. 2021 Jun, 15(6), 1647-1666, doi: 10.1002/1878-0261.12869.

Wang L., Lu J., Marchenko S.A., Monuki E.S., Flanagan L.A., Lee A.P., *Dual Frequency Dielectrophoresis with Interdigitated Sidewall Electrodes for Microfluidic Flow-Through Separation of Beads and Cells*, Electrophoresis, 30, 782-791 (2009).

Zahedi Siani O., Sojoodi M., Zabetian Targhi M., Movahedin M., *Blood Particle Separation Using Dielectrophoresis in a Novel Microchannel: A Numerical Study*, Cell J. 2020 Jul, 22(2), 218-226, doi: 10.22074/cellj.2020.6386.

ROLUL DIELECTROFOREZEI ÎN DETECŢIA ŞI SEPARAREA CELULELOR TUMORALE CIRCULANTE

(Rezumat)

Dielectroforeza este o metodă de manipulare, inclusiv separare, de particule țintă (nano şi/sau microparticule, celule vii) în prezența unui câmp electric neuniform. În ultimii ani, metoda şi-a găsit numeroase aplicații în domenii bio-medicale, cu precădere în oncologie, mai exact în studiul celulelor tumorale circulante. Celulele tumorale circulate sunt celule eliberate de către o tumoră încă din fazele inițiale ale procesului de metastazare, când tumorile secundare nu pot fi încă detectate prin metode imagistice clasice. Astfel, dielectroforeza poate fi o metodă adjuvantă utilă în detecția mai precoce a cancerului. În acest context, acest articol oferă o nouă perspectivă asupra unui subiect de interes în prezent. Prezentând în primele două părți în detaliu tehnica dielectroforezei şi caracteristicile fizico-biologice ale celulelor tumorale circulante, articolul enumeră pe final cele mai relevante şi recente aplicații ale acestei tehnicii în domeniul celulelor tumorale, deschizând posibile direcții viitoare de cercetare.