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M. G. Tomilin [a], A. A. Kilanov [a] & S. A. Povzun [a b]

[a] S. I. Vavilov State Optical Institute, St. Petersburg, 199034, Russia

[b] Pathology Department of Military Medical Academy

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LC Vision: New Application in Cancer Detection

M.G. TOMILIN, A.A. KILANOV and S.A. POVZUN*

S.I. Vavilov State Optical Institute, St. Petersburg, 199034, Russia

The thin layers of homogeneously oriented NLC applied on the surface under investigation as a free film can be used as unusual recording media that permits to visualize the two-dimensional distribution of surface tension with high optical resolution and sensitivity. The changes of surface tension may detect different local defects without applying external electrical fields. On this basis a new non-destructive method to study the quality of different material surfaces has been developed. Here we discuss the new application of NLC technique for histological identification of malignancies.

Keywords: Nematics; surface tension; orientation; visualization; cancer

INTRODUCTION

The initial nematic liquid crystal (NLC) structure ordering is the physical basis for visualizing the two-dimensional distribution of surface tension that can detect local defects on the surface of different materials. This order may be disturbed under the influence of structural inhomogeneities

* Pathology Department of Military Medical Academy

and defects of the surface [1]. In practice the investigation of the influence of spatially inhomogeneous fields on NLC structure is particular vital for different application areas. Previously the NLC technique was efficiently used in crystallography [2], mineralogy [3], metallography [4] and optical technology [5]. The NLC technique that gives the possibilities to observe the distribution of invisible low power physical fields and particular the distribution of surface tension was called LC vision [6]. The theory of LC vision that gives the relation between the image size of defects in the NLC layers and their real size was developed. It was examined in comparison with experiments and gave a good correlation [7]. The achievements in the application of LC vision in material science stimulated our experiments in application of LC vision in medicine. The first investigations in human tissue pathology diagnostics gave a positive result [8].

THE EXPERIMENTAL TECHNIQUE

The problem of cancer is one of the corner stones in medicine. It is not only the problem of surgical and therapeutical management of malignancies. In some cases, there exists the problem of the microscopic differential diagnosis between malignant and benign neoplasm. The routine method of tissue specimen preparation for histological examination is based on organic dyes application. It consists of cutting the frozen tissue or tissue embedded in paraffin using a microtome, mounting optically transparent sections of 4-5 mm thick on the object glasses and staining them with hematoxylin and eosin or other pair of dyes to differentiate nuclei and cytoplasm in tissues th

at naturally are colorless (Fig. 1a).

In most cases, histological diagnosis of cancer is clear-features of cellular atypia and invasive growth are enough to provide a certain conclusion. However, in some instances these features are not sufficiently prominent that morphological diagnosis is based more on pathologist's intuition than on concrete facts.

The main difficulty in detecting the pathology on the surface of human tissue is its own very complicated structural inhomogeneity in comparison with other technical applications. It is well known that the malignant tissue has some different biological and chemical characteristics than its benign analogue. But there is no exact information about any unique physical properties of malignant tissues. It is also difficult to imagine that anybody ever measured the value of its surface tension.

We suggested that NLC layer applied on the malignant tissue surface could show some new features that will help to detect it. We examined many hundreds of probes and came to the conclusion that only frozen tissues could be studied using LC vision. We studied 12 obvious cases of malignant tumours using optical microscope. The sections were prepared of the same tissue blocks and stained with routine histological technique. Four samples of non-malignant histopathology served as control group.

In order to avoid the orientation of NLC molecules induced by the deposition technique, we used the mixture of NLC and the solvent alcohol or acetone. The solvent transformed the nematic to the isotropic phase. When the mixture was deposited on the surface the solvent evaporated and NLC molecular orientation was determinated only by the structural topography. After examination of the NLC structures at regions

:e tension anomalies through a polarizing microscope their /ere recorded (Fig.1b).

MENTAL RESULTS

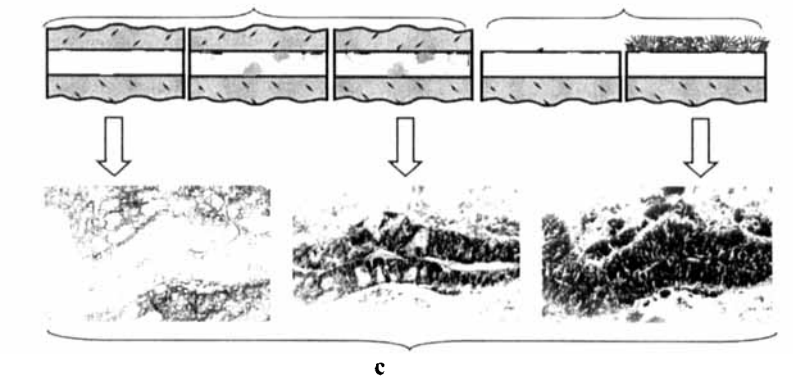
ied malignancies of various histogenetic groups:

epithelium (solid cancer of stomach, well differentiated colon ocarcinoma, rectal adenocarcinoma, squamous cancer of skin, st cancer, cancer of lung);

i tissues of mesenchimal genesis (leyomyosarcoma of breast);

i haemopoietic tissue (non-Hodgkin's lymphoma of skin);

i melanin-producing tissue (melanoblastoma of skin).



c

:E 1. Models of tissue decorated with dyes (a) and NLC (b). Rectal (c): 1- native tissue section; 2- tissue section stained with dyes; 3- section decorated with NLC. Malignant tissue looks dark on bright ound of tumorouless structure. Magnification 80^{x}.

As a control group fibroadenoma of breast, fibroma of skin, angioleyomyoma of neck and skin nevus were examined. It was found that all tissues except malignant foci were decorated in colors with NLC. These foci always looked dark with exception of blood vessels and elements of fibrous stroma within them that looked bright. Fig.1c shows the difference in image of rectal cancer tissue section for 3 cases: stained with dyes, native and decorated with NLCs.

DISCUSSION

The fact that malignant cells coated with NLC looked dark through the polarizing microscope with crossed analyzer and polarizer means that in this case NLC molecules had a homeotropic orientation. The only reason for this phenomenon is a large difference in the value of surface energy between malignant tissue and benign analogue. It is well known that the homeotropic orientation takes place when the surface tension of NLC layer is much bigger than the surface tension of the substrate (tissue) [9] (Fig.2).

If the surface tension of tissue and NLC were of the same value there would be a tilted orientation of NLC molecules on benign tissue (Fig.2). This fact gives a new criterion for histological identification of malignancies and makes NLC to be a unique recording material for visualizing the topographical distribution of surface tension on human tissues.

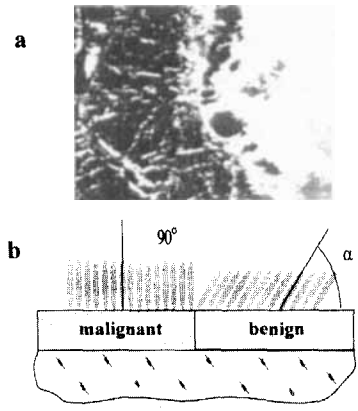


FIGURE 2. Photo of rectal cancer (adenocarcinoma): malignant (left) and benign (right) tissues decorated by NLC layer (**a**). The NLC molecule orientation model on tissue (**b**). It depends on the surface tension value of NLC and tissue.

The discovered phenomenon may be applied in histopathology for identification of tumours especially in questionable diagnostic situations. Some additional examples are shown on Fig.3. The difference in surface tension of malignant and benign tissues was confirmed by independent experiments with droplets of pure water and alcohol that showed different values for contact angles.

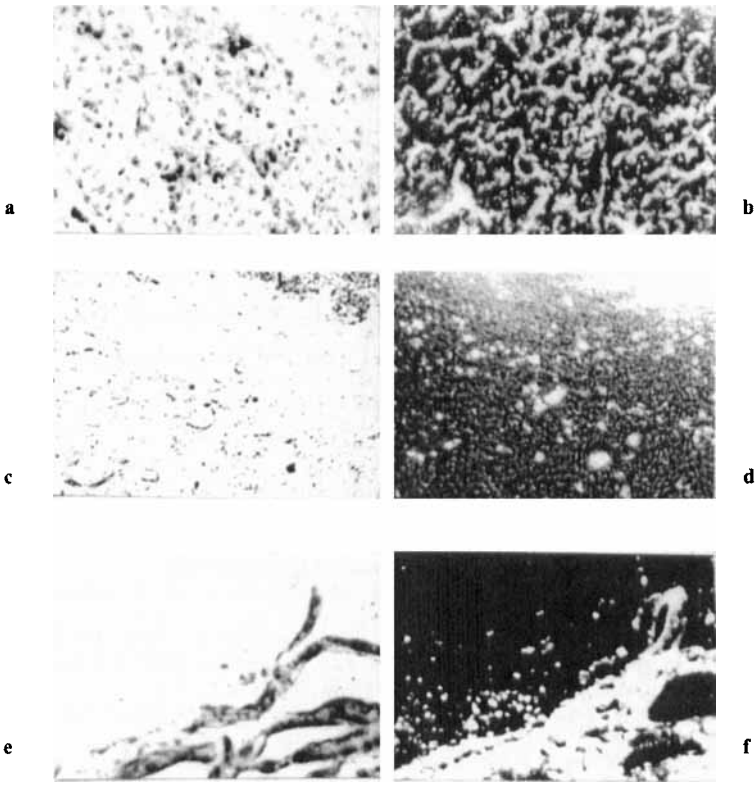


FIGURE 3. Different types of malignant tissues: native tissue sections without any staining (left) and tissues decorated with NLC (right). Malignant tissue covered with NLC looks dark: a, b – melanoblastoma of skin; c, d – small-cell cancer of lung; e, f – leyomyosarcoma of breast. Magnification 100^x.

CONCLUSION

The first application of LC vision to cancer detection is described. The new biophysical criterion based on the low value of malignant tissue surface energy in comparison with its benign analogue is discovered. The new phenomenon is observed as homeotropic orientation of NLC molecules only on malignant tissue while on its benign analogue the NLC molecules have a tilted orientation. LC vision opens new ways in differential microscopic diagnosis of cancer and may be used for tissue pathology visualization in medicine and biology.

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