The polymer composites consist of polymer matrix and a modifier which is dispersed in it improving the properties of the matrix or giving it completely new features. These are bi- or multi-component systems which may be modified by the selection of the art and amount of the component as well as by its arrangement.

These materials are characterized by the unique properties like good mechanical strength, low density (resulting in low product weight), possibility of forming any shape, resistance to destructing factors (including corrosion), ease of processing and modification. Therefore they are valuable materials applied in many disciplines of the contemporary economy like materials in civil engineering, elements of the machines, automobiles, ships, aviation, medical equipment, sport and household.

Majority of the polymers and their composites have insulating properties, i.e. they are good dielectrics to be applied in electric and electronic equipment. After their polarization in the strong electric field over 40V/μm they show the ability of collecting ordered electric charges in their structure. It comes from the charge that already was included in the polymer (e.g. dipoles, pointwise defects) and has been ordered, or the charge that has been introduced into the polymer structure during the polarization. Durably polarized dielectrics become electrets.

The electrets show the piezoelectric properties, i.e. under the mechanical load of the polymer film which is placed between the electrodes (or contact electrodes) the electric potential arises. In reverse effect, the electric field put to the electrodes causes the distortion of the film. The practical meaning have only those, the depolarization period of which attains several years. They may be used in production of the microphones, loudspeakers, as well as motor-operators. They may also be used in production of different sensors of active surfaces ranging from cm^2 to 1 m^2 or more. Because of its flexibility, the thickness from several to some tens of microns and possibility of shaping surface they may be placed between different parts of the machine informing about the state of the wear. They may be transformers of the mechanical into electric energy what may have the application in alarming sensors supporting life systems. The most considerable feature of these sensors is that they do not require the additional power supply of the active element.

The most recognized piezoelectric polymer is poly(vinylidene fluoride), PVDF. However, because of its complicated and high manufacturing costs, new effective polymers, cheaper and easier to produce are wanted. It might enable wider application of piezopolymers.

To these polymers belong polyolefins (polymeric hydrocarbons) like polyethylene and polypropylene. However, the basic disadvantage of these materials is their low melting temperature. Introducing the mineral fillers e.g. aluminosilicates like kaolin or montmorillonite into the polymer matrix causes the increase of the melting temperature of the composite. The high crystalline degree also enhances the thermal strength. The more crystalline phase, the more resistant polymer. Orientation of the film, i.e. uni- or biaxial stretching also enhances the share of the crystalline phase in the material.

The basic feature of the piezopolymers is piezoelectric constant. The problem is to reach the d_{33} constant value (when the acting direction of the force is perpendicular to the surface of the piezo-film) similar to this one for piezoceramic materials. The presence of air cavities (voids) makes this situation possible. The formation of the cellular structure causes the higher distortion of the cellular material compared to solid one subjected to the same mechanical load. It also inhibits the electric charge flow in the material. Both processes have influence on enhancement of the value of the piezoelectric constant d_{33}. The thermal resistance of the composite of cellular structure increases because the thermal conduction of the air is lower than of the polymer. Introducing the crystalline silica SiO_2 (or other inorganic modifier) into the composite we form the cellular structure because the SiO_2 grains are poorly wetted by the polymer. There are the air cavities around the grains which enhance their volume during the stretching process.

Above mentioned way of manufacturing composites of good thermal strength and high piezoelectric constant is based on our preliminary investigation.

To optimize the obtained results, the chemical composition of the said materials as well as the method of the film manufacturing and orientation should be established. Moreover, the polarization conditions have to be properly chosen.

Adequate conducting of those processes has great influence on quality of the electrets, therefore, the problem to be solved is now very important and topical. The introduction of the crystalline filler to get the cellular structure is really innovative.

The phenomena occurring in electrets, i.e. the dependence between material structure, electric charge entrapping and transport, mechanical and electric properties have many unknown points. The realization of project may contribute in solving existing problems.

The work methodology comprises the advanced testing and processing techniques. Piezoelectric composites in the form of films will be obtained by extrusion method, then subjected to polarization or corona discharge to form the electrets. The detailed procedure concerning manufacturing of durable electrets depending on composition and composite morphology, processing and modification conditions will be worked out.

The key stage of the research comprises the investigation of the properties and the durability of the electrets as well as the explanation of the electric charge entrapping mechanism in polyolefin composites containing kaolin, montmorillonite and silica. In this case characteristic parameters for piezoelectric materials like piezoelectric constant, depolarization time, the factor of the mechanical coupling as well as an angle of phase shifting between the real and imaginary constant.

Other basic physicochemical properties of the composites will be determined including morphology, crystalline degree, spectroscopic properties, thermal and photochemical stability.

The following techniques will be used: X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic forces microscopy (AFM), IR spectroscopy (FTIR), mechanical tests (stretching, compacting), thermogravimetry (TGA), thermostimulated discharge currents (TSDC), impedance spectroscopy, non-contact ultrasonic spectroscopy (NCUS).

The knowledge concerning dependence of composite properties vs. chemical structure and internal structure (morphology) is very important not only because of the cognitive point of view but it also may contribute to designing new materials of wanted functional features. The predicted applications of the polymer composites showing durable piezoelectric effect comprise sensors for constructing electro-acoustic and electro-mechanical systems.

To fulfill the realization of the present project, the consortium has been established including Faculty of Chemistry at Nicolaus Copernicus University in Toruń, Institute for Engineering of Polymer Materials and Dyes in Toruń and Institute for Electronic Technology in Warsaw (Cracow division). The executors of the project are highly qualified staff having long-term experience in

polymer processing technology and well equipped laboratories.
Within the project the purchase of the apparatus for the non-contact ultrasonic spectroscopy (NCUS) is foreseen as well as the execution of the composite film orienting device.
During the realization of the project the work-place for one person (young scientist) for two years is also foreseen.