

CATHEPSIN DETECT™

Assay Kit for Cathepsin B, K, and L

Contact Information

Address	Cell Technology, Inc. 2010 East Hennepin Ave. Suite 203 Minneapolis, MN 55413 USA
Telephone	(612) 331-5429
Fax	(612) 331-4704
General Information	info@celltechnology.com
Sales	sales@celltechnology.com
Technical Questions	techsupport@celltechnology.com
Website	www.celltechnology.com



CELL TECHNOLOGY

I. Introduction

Background

Elevated cathepsin enzyme activity in serum or the extracellular matrix often signifies a number of gross pathological conditions. Cathepsin-mediated diseases include: Alzheimer's; numerous types of cancer; autoimmune related diseases such as arthritis; and the accelerated breakdown of bone structure seen with osteoporosis (1,2). Up-regulated cathepsin B and L activity has been linked to several types of cancer. These include cancer of the colon, pancreas, ovaries, breast, lung, and skin (melanoma) (3-6). Up-regulation of cathepsin K has been shown in lung tumors (8). Increased cathepsin K activity has also been linked to degenerative bone diseases including osteopetrosis and post-menopausal osteoporosis (1,7).

Cathepsins are usually characterized as members of the lysosomal cysteine protease (active site) family (9), and the cathepsin family name has been synonymous with lysosomal proteolytic enzymes (1). In actuality, the cathepsin family also contains members of the serine protease (cathepsin A,G) and aspartic protease (cathepsin D,E) families as well. These enzymes exist in their processed form as disulfide-linked heavy and light chain subunits with molecular weights ranging from 20-35 kDa (10). Cathepsin C is the noted exception, existing as an oligomeric enzyme with a MW ~200 kDa (10). Initially synthesized as inactive zymogens, they are post-translationally processed into their active configurations after passing through the endoplasmic reticulum and subsequent incorporation into the acidic environment of the lysosomes (1,10).

Assay Principle

Protease activity can be detected within whole living cells using Cell Technology's Cathepsin Detect™ substrate-based assay kits. These kits allow researchers to quickly visualize intracellular cathepsin activity within their particular experimental cell line.

Cell Technology's Cathepsin Detect™ detection kits utilize the fluorophore cresyl violet. When bi-substituted via amide linkage to two cathepsin target sequence peptides {such as (Arginine-Arginine)₂}, the cresyl violet leaving group is non-fluorescent (11). Following enzymatic cleavage at one or both arginine (R) amide linkage sites, the mono and non-substituted cresyl violet fluorophores generate red fluorescence when excited at 550-590 nm.

Cell Technology has taken (z-Arginine-Arginine)₂ abbreviated as (z-RR)₂, (z-Leucine-Arginine)₂ abbreviated as (z-LR)₂, and (z-Phenylalanine-Arginine)₂ abbreviated as (z-FR)₂ derivatives of the cresyl violet fluorophore (synthesized by Enzyme Systems Products) and incorporated them into user-friendly assay kits. These Cathepsin Detect photostable fluorogenic substrates easily penetrate the cell membrane and the membranes of the internal cellular organelles enabling researchers to detect cathepsin activity within whole living cells.

Intracellular cresyl violet substrate hydrolysis can be monitored by the accumulation of red fluorescent product within various organelles. By varying the duration and concentration of exposure to the Cathepsin Detect substrate, a picture can be obtained of the relative abundance and intracellular location of cathepsin enzyme activity. This activity can be monitored using a fluorescence microscope or microtiter plate fluorometer.

The unsubstituted red fluorescent Cathepsin Detect product has an optimal excitation and emission wavelength pairing of 592 nm and 628 nm respectively. At these higher excitation wavelengths, the amount of cell-mediated auto-fluorescence is minimal (11). Fortunately, the excitation peak of this fluorophore is rather broad allowing good excitation efficiency at 540-560 nm. The typical mercury lamp used in fluorescence microscopy has a maximum light output at 542 nm, which is quite compatible with the Cathepsin Detect™ substrate.

Hoechst stain is included and can be used to label the cell nuclei after labeling with the Cathepsin Detect reagent. It is revealed under a microscope using a UV-filter with excitation at 365 nm and emission at 480 nm.

In addition, acridine orange (AO) is included in the kit to help identify lysosomes and other intracellular organelles. The acidic pH of the lysosome results in the concentration and aggregation of the AO molecules. Aggregated AO molecules fluoresce orange rather than green thus clearly differentiating the lysosomes from the other organelles (see figure 7) (13).

Cell Technology offers 3 different Cathepsin Detect™ Cathepsin products: Cathepsin Detect (RR)₂ to detect cathepsin B; Cathepsin Detect (LR)₂ to detect cathepsin K; and Cathepsin Detect (FR)₂ to detect cathepsin L.

II. Warnings and Precautions

1. Use gloves while handling the Cathepsin Detect reagent, AO, and Hoechst stain.
2. Dispose of all liquid components down the sink and flush with copious amounts of water. Solid components may be tossed in standard trash bins.
3. MSDS sheets are available at <http://www.celltechnology.com/> or by calling 612-331-5429.

III. Storage and Shelf Life

1. Store the unopened kit (and each unopened component) at 2°C to 8°C until the expiration date.
2. Protect the Cathepsin Detect reagent from light at all times.
3. Once reconstituted, the 260X Cathepsin Detect stock should be stored at or below –20°C protected from light. This reagent is stable for 6 months and may be thawed twice during that time.

IV. Kit Content

A. Cathepsin Detect for cathepsin B

Catalog#: CDK100-1 Tests: 25

1. Cathepsin Detect (RR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

B. Cathepsin Detect for cathepsin B

Catalog#: CDK100-2 Tests: 100

1. Cathepsin Detect (RR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

C. Cathepsin Detect for cathepsin K

Catalog#: CDK200-1 Tests: 25

1. Cathepsin Detect (LR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

D. Cathepsin Detect for cathepsin K

Catalog#: CDK200-2 Tests: 100

1. Cathepsin Detect (LR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

E. Cathepsin Detect for cathepsin L

Catalog#: CDK300-1 Tests: 25

1. Cathepsin Detect (FR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

F. Cathepsin Detect for cathepsin L

Catalog#: CDK300-2 Tests: 100

1. Cathepsin Detect (FR)₂ reagent, lyophilized
2. Hoechst 33342 stain, 1 mL
3. Acridine orange (AO), 0.5 mL

V. Materials Required But Not Supplied

1. Cultured cells with media
2. Reagents to induce apoptosis or other experimental condition
3. 15 mL polypropylene centrifuge tube (1 per sample)
4. Amber vials or polypropylene tubes for storage of 260X concentrate at -20°C , if aliquoted
5. Slides and coverslips
6. Hemocytometer
7. Clinical centrifuge at 200 X g
8. 37°C CO_2 incubator
9. Pipette(s) capable of dispensing at 10, 50, 200, or 300 μL , 1mL
10. dH_2O , up to 2 mL needed
11. Phosphate buffered saline (PBS) pH 7.4, up to 100 mL needed
12. Dimethyl sulfoxide (DMSO), 50 or 200 μL needed
13. Trypsin-versine
14. Ice or 4°C refrigerator to store cells

VI. Experimental Preparation and Setup

Hoechst 33342 Stain

Hoechst stain can be used to label the cell nuclei after labeling with the Cathepsin Detect reagent. It is revealed under a microscope using a UV-filter with excitation at 365 nm and emission at 480 nm. Hoechst stain is provided ready-to-use at 200 $\mu\text{g}/\text{mL}$.

Warning: Hoechst stain is a potential mutagen. Use of gloves, protective clothing, and eyewear are strongly recommended. When disposing, flush sink with copious amounts of water; see MSDS for further information.

Acridine Orange

Acridine orange (AO) is a chelating reagent and can be used to reveal lysosomes, nuclei, and nucleoli. 0.5 mL of AO is provided at 1 mM. AO may be used neat or diluted in dH_2O or media prior to pipetting into the cell suspension. Always protect AO from bright light.

Lysosomal structures can be visualized using AO concentrations ranging from 0.5 to 5.0 μM . This concentration range can be obtained by diluting the AO reagent stock 1:2000 to 1:200 (0.05 – 0.5% v/v) into the final cell suspension. For example, if using AO at 1 μM in the final cell suspension, first dilute the AO 1:100 in dH_2O : put 10 μL AO into 990 μL dH_2O . Then pipette the AO into the cell suspension at 1:10: put 55.5 μL diluted AO into 500 μL cell suspension.

As AO exhibits a very broad emission range, one of several filter pairings on the fluorescence microscope can be used to view this stain. The same excitation/emission filters used to view the Cathepsin Detect can also be used: a 550 nm (540-560 nm) excitation and long pass >610 nm emission/barrier filter pairing. In this case, the lysosomes will appear red.

When illuminating with a blue light (480 nm) excitation filter, a green light (540-550 nm) emission/barrier filter combination works well. Lysosomes will appear yellowish green instead of

red. As this filter combination is very close to the maximum emission of AO, the slide may appear too bright. Cells read at this combination may need to be washed prior to viewing to remove any excess AO.

Because of the emissions overlap, dual staining of cells with both Cathepsin Detect and AO will yield confusing results. Therefore these dyes should not be used to stain the same cells.

Warning: AO is a potent mutagen and probable carcinogen. Use of gloves, protective clothing, and eyewear are strongly recommended. When disposing, flush sink with copious amounts of water; see MSDS for further information.

Reconstitution of the 260X Cathepsin Detect Stock

The Cathepsin Detect reagent is a highly concentrated lyophilized powder. It must first be reconstituted in DMSO, forming a 260X stock concentrate, and then diluted 1:10 in PBS to form a final 26X working solution. For best results, the 26X working solution should be prepared immediately prior to use; however, the reconstituted 260X stock concentrate can be stored at or below -20°C for future use.

The newly reconstituted 260X Cathepsin Detect stock must be used or frozen immediately after it is prepared and protected from light during handling.

1. Reconstitute the vial of lyophilized Cathepsin Detect with DMSO to yield a 260X concentrate.
 - a. For the 25-test vial, add 50 μL .
 - b. For the 100-test vial, add 200 μL DMSO.
2. Mix by swirling or tilting the vial, allowing the DMSO to travel around the base of the vial until completely dissolved. At room temperature (RT), the reagent should be dissolved within a few minutes.
3. If immediately using this solution, dilute it to 26X (Section 11).
4. Or, if using later, aliquot and store it at or below -20°C (Section 12).

Preparation of 26X Cathepsin Detect Solution for Immediate Use

Using the freshly reconstituted 260X Cathepsin Detect stock, prepare the 26X working-strength Cathepsin Detect solution by diluting the stock 1:10 in PBS. Following the suggested protocols here, each 0.5 mL sample to be tested requires only 20 μL of 26X Cathepsin Detect solution (or 2 μL of the 260X Cathepsin Detect stock).

1. For the 25-test vial, if using the entire vial, add 450 μL PBS (the vial contains 50 μL of the 260X stock; this yields 500 μL of a 26X solution).
2. For the 100-test vial, if using the entire vial, add 1.8 mL PBS (the vial contains 200 μL of the 260X stock; this yields 2 mL of a 26X solution).
3. If not using the entire vial, dilute the 260X stock 1:10 in PBS. For example, add 10 μL of the 260X stock to 90 μL PBS (this yields 100 μL of a 26X solution). Store the unused 260X stock at or below -20°C (Section 12).
4. Mix by inverting or vortexing the vial at RT.

The 26X working strength Cathepsin Detect solution must be used the same day that it is prepared.

Storage of 260X Cathepsin Detect Stock for Future Use

If not all of the 260X Cathepsin Detect stock will be used the same time it is reconstituted, the unused portion may be stored at or below -20°C for 6 months. During that time, the 260X Cathepsin Detect stock may be thawed and used twice. After the second thaw, discard any remaining 260X Cathepsin Detect stock. If you anticipate using it more than twice, make small aliquots in amber vials or polypropylene tubes and store at or below -20°C protected from light. When ready to use, follow Section 13 below.

Preparation of 26X Cathepsin Detect Solution from a Frozen Aliquot

If some of the 260X Cathepsin Detect reagent was previously reconstituted and then stored at or below -20°C , it may be used 2 more times within 6 months.

1. Thaw the 260X Cathepsin Detect stock and protect from light.
2. Once the aliquot has become liquid, dilute the 260X stock solution 1:10 in PBS and vortex. For example, mix 10 μL of 260X Cathepsin Detect reagent with 90 μL PBS.
3. If the 260X Cathepsin Detect stock was frozen immediately after reconstitution and was never thawed, return it to the freezer. If the stock was thawed once before, discard it.
4. Proceed to the labeling protocol (Section 14 or 15).

Fluorescence Microscopy Staining Protocol for Suspension Cells

1. Culture cells to a density optimal for the cell line being studied.
2. Cultivate or concentrate cells to a density of at least 5×10^5 cells/mL. Cells may be concentrated by centrifugation just prior to staining.

Cell density in the cell culture flasks should not exceed 10^6 cells/mL. Cells cultivated in excess of this concentration may begin to naturally enter apoptosis due to nutrient deprivation or the accumulation of cell degradation products in the media. Optimal cell concentration will vary depending on the cell line used.

3. Expose cells to the condition being investigated.
4. At the same time, culture an equal volume of negative control cells for use as a reference population. Make sure that both the experimental (positive) cell population tubes and the negative control tubes contain similar quantities of cells.

When ready to label with the 26X Cathepsin Detect solution, cells should be between 5×10^5 – 2×10^6 cells/mL for best viewing.

5. If necessary, concentrate cells by gentle centrifugation at $200 \times g$ for 3 –8 minutes.
6. Prepare the 260X stock by reconstituting the vial of lyophilized Cathepsin Detect with 50 μL (25-test vials) or 200 μL (100-test vials) DMSO (Section 10).
7. Prepare the 26X stock by diluting the reconstituted vial with 450 μL (25-test vials) or 1.8 mL PBS (100-test vials) (Section 11).
8. Transfer 500 μL of each induced and negative control cell populations into fresh 12 x 75 mm glass or polypropylene tubes. Or, if desired, larger cell volumes can be used, however more of the 26X Cathepsin Detect solution may be required. Larger volume cell suspensions label nicely using 25 cm^2 tissue culture flasks (laid flat) as incubator vessels.
9. Add 20 μL of the 26X Cathepsin Detect solution directly to each 500 μL cell suspension forming a final volume of 520 μL .

10. Or, if a different volume was used, add the 26X Cathepsin Detect solution at a 1:26 ratio of the final volume. For example, if 1 mL of cell suspension was used, add 40 μL of the 26X Cathepsin Detect solution forming a final volume of 1,040 μL . (To optimize this assay to your specific research conditions, adjust the amount of 26X Cathepsin Detect used to determine the greatest difference in the fluorescence signal between positive and negative cell populations.)

Each investigator should titrate the amount of Cathepsin Detect used to accommodate their particular cell line and research conditions.

11. Mix the cells thoroughly.
12. Incubate cells for 15 to 60 minutes at 37°C under 5% CO₂, protecting the tubes from light. As cells may settle on the bottom of the tubes, gently resuspend them by swirling the tubes every 20 minutes during this incubation time. This will ensure an even distribution of the Cathepsin Detect reagent among all cells. (To optimize this assay to your specific research conditions, adjust this incubation time to determine the greatest difference in the fluorescence signal between positive and negative cell populations.)

Each investigator should adjust the incubation time to accommodate their particular cell line and research conditions.

13. At this point, the cells may be stained with Hoechst stain (Section 8), or AO (Section 9).
14. If cells are to be monitored using Hoechst stain (Section 8):
 - a. Add 2.5 μL Hoechst stain (0.5% v/v) to the 520 μL cell suspension labeled with Cathepsin Detect.
 - b. Or, add 2.5 μL Hoechst stain (0.5% v/v) to a 500 μL cell suspension that was not labeled.
 - c. Incubate for an additional 5 – 10 minutes at 37°C under 5% CO₂.
 - d. Go to Step 16.
15. If cells are to be stained with AO (Section 9) instead of Cathepsin Detect, pipette the AO reagent stock 1:2000 to 1:200 (0.05 – 0.5% v/v) into the final cell suspension. (Because of the emissions overlap, dual staining of cells with both Cathepsin Detect and AO will yield confusing results.)
 - a. For example, if using AO at 1 μM in the final cell suspension, first dilute the AO 1:100 in diH₂O: put 10 μL AO into 990 μL diH₂O. Then pipette the diluted AO into the cell suspension at 1:10: put 55.5 μL diluted AO into 500 μL cell suspension.
 - b. Incubate an additional 30 minutes at 37°C under 5% CO₂
 - c. If viewing under the same filters used for the Cathepsin Detect staining (excitation at 550 nm, emission >610 nm), cells may be viewed immediately after staining, without a wash step - go to Step 16.
 - d. If viewing under blue (480 nm) excitation and green (540-550 nm) emission wavelengths, cells may need to be washed with PBS to remove any excess AO as the cells may appear too bright. Brightness will depend on the type of microscope used, and the type of cell line. To wash the cells:
 - i) Gently pellet cells at 200 X g for 3-8 minutes at RT.
 - ii) Remove and discard supernatant.
 - iii) Resuspend cells in a similar volume of PBS.
 - iv) Go to Step 16.
16. Place 15 – 20 μL of the cell suspension onto a microscope slide and cover with a coverslip.
17. Observe Cathepsin Detect stained cells using a fluorescence microscope equipped with an excitation filter of 550 nm (540 – 560 nm) and a long pass >610 nm emission/barrier filter pairing. (If these filters are not available, select a filter combination that best approximates these settings.) Using this excitation/emission filter pairing, cells should stain red with more brightly stained vacuoles and lysosomes.

18. If the same sample was stained with both Cathepsin Detect and Hoechst, and if a multi-wavelength filter option is available on the fluorescence microscope, the dual staining properties of the sample can be examined. Hoechst stain can be seen using a UV-filter with excitation at 365 nm and emission at 480 nm. If these exact filter pairings are not available, select a filter combination that best approximates these settings.
19. As AO exhibits a very broad emission range, one of several filter pairings on the fluorescence microscope may be used. The same excitation/emission pairing filters used to view the Cathepsin Detect may be used: a 550 nm (540-560 nm) excitation and long pass >610 nm emission/barrier filter pairing. In this case, the lysosomes appear red. When illuminating with a blue light (480 nm) excitation filter, a green light (540-550 nm) emission/barrier filter combination works well. Lysosomes will appear yellowish green instead of red. Because of the emissions overlap, dual staining of cells with both Cathepsin Detect and AO will yield confusing results. Therefore, these dyes should be used separately.
20. To optimize this assay for your specific research conditions, vary the amount of 26X Cathepsin Detect used (Step 8), and the incubation time (Step 12) to determine the greatest difference in the fluorescence signal between positive and negative cell populations.

Fluorescence Microscopy Staining Protocol for Adherent Cells

1. Select the cell culture flask containing the cells that will be studied and dislodge the attached cells.
 - a. Aseptically remove the media from the flask.
 - b. Depending on the size of your culture flask, aseptically add 5 - 25 mL sterile PBS or saline to the flask.
 - c. Aseptically remove this solution and discard.
 - d. Add trypsin-versine to the flask, varying the amount depending on the flask surface area. For example, a 25 cm² flask should receive approximately 1 mL of the trypsin reagent; a 75 cm² flask should receive approximately 3 mL.
 - e. Incubate the flask for 1-2 minutes, rocking the flask gently back and forth to dislodge the attached cells.
 - f. To neutralize the trypsin activity and count the cells, dilute the contents of the flask 1:20 into culture media. For example, take 1 mL of suspension and add to a sterile culture tube containing 19 mL of the complete cell culture media (with serum).
 - g. Count the cells using a hemocytometer.
2. Seed about 10⁴ – 10⁵ cells onto a sterile coverslip in a 35 mm petri dish or onto chamber slides.
3. Grow the cells using your culture media formulation until about 80% confluent. This usually takes about 24 hours, but will vary with your cell line.
4. Expose cells to your experimental conditions.
5. Remove samples of the cell overlay media at time points according to your specific protocol. The precise volume used should be optimized to your specific conditions. For example, if working in a microtiter plate, 300 µL samples may be appropriate, or if working in a chamber slide, 1 mL or more of the sample may be necessary.
6. Add the 26X Cathepsin Detect solution directly to each sample at a ratio of 1:26. For example, if 300 µL was used, add 12 µL of the 26X Cathepsin Detect solution forming a final volume of 312 µL. If 1,000 µL was used, add 40 µL of the 26X Cathepsin Detect solution forming a final volume of 1,040 µL.
7. Optimize this assay to your specific research conditions by adjusting the volume of sample used and the volume of 26X Cathepsin Detect used to determine the greatest difference in the fluorescence signal between positive and negative cell populations.

Each investigator should titrate the amount of Cathepsin Detect used to accommodate their particular cell line and research conditions.

8. Gently mix the cell overlay media to ensure even exposure to the Cathepsin Detect.

9. Incubate cells for 30 - 60 minutes at 37°C in a CO₂ incubator.
10. Remove the media.
11. Rinse twice with PBS, 1 minute per rinse.
12. At this point, labeled and unlabeled cells can be stained with Hoechst stain (Section 8), and unlabeled cells can be stained with AO (Section 9).
13. If cells are to be monitored using Hoechst stain (Section 8):
 - a. Add 5.2 μL Hoechst stain (0.5% v/v) to the 1040 μL of cell overlay material labeled with Cathepsin Detect.
 - b. Or, add 5.2 μL Hoechst stain (0.5% v/v) to a 1040 μL cell suspension that was not labeled.
 - c. Incubate for an additional 5 – 10 minutes at 37°C under 5% CO₂.
 - d. Go to Step 15.
14. If cells are to be monitored using AO (Section 9):
 - a. Pipette the AO reagent stock 1:2000 to 1:200 (0.05 – 0.5% v/v) into the final cell overlay media. Because of the emissions overlap, dual staining of cells with both Cathepsin Detect and AO will yield confusing results. Therefore, the dyes should be used separately.

- b. For example, if using AO at 1 μM in the final cell media, first dilute the AO 1:100 in dH_2O : put 10 μL AO into 990 μL dH_2O . Then pipette the diluted AO into the cell overlay media at 1:10: put 111 μL diluted AO into 1000 μL cell overlay media forming a final volume of 1111 μL .
 - c. Incubate for an additional 30 minutes at 37°C under 5% CO_2 .
 - d. Remove the media from the cell mono-layer surface.
 - e. Rinse twice with PBS, 1 minute per rinse.
 - f. Go to Steps 15 and 18.
15. Mount the coverslip with cells facing down onto a drop of PBS. If a chamberslide was used, pull off the plastic frame and add a drop of PBS to the cell surface and cover with a coverslip.
 16. Observe Cathepsin Detect stained cells using a fluorescence microscope equipped with an excitation filter of 550 nm (540 – 560 nm) and a long pass >610 nm emission/barrier filter pairing. (If these filters are not available, select a filter combination that best approximates these settings.) Using this excitation/emission filter pairing, cells stain red with more brightly stained vacuoles and lysosomes.
 17. If the same sample was stained with both Cathepsin Detect and Hoechst, and if a multi-wavelength filter option is available on the fluorescence microscope, the dual staining properties of the sample can be examined. Hoechst stain can be seen using a UV-filter with excitation at 365 nm and emission at 480 nm. If these exact filter pairings are not available, select a filter combination that best approximates these settings.
 18. As AO exhibits a very broad emission range, one of several filter pairings on the fluorescence microscope may be used. The same excitation/emission pairing filters used to view the Cathepsin Detect may also be used: a 550 nm (540-560 nm) excitation and long pass >610 nm emission/barrier filter pairing. Lysosomes will appear red. When illuminating with a blue light (480 nm) excitation filter, a green light (540-550 nm) emission/barrier filter combination works well. In this case, lysosomes will appear yellowish green instead of red. Because of the emissions overlap, dual staining of cells with both Cathepsin Detect and AO will yield confusing results. Therefore, these dyes should be used separately.
- To optimize this assay for your specific research conditions, vary the amount of 26X Cathepsin Detect used (Step 5), and the incubation time (Step 9) to determine the greatest difference in the fluorescence signal between positive and negative cell populations.

References

1. Buhling F, Fengler A, Brandt W, Welte T, Ansorge S, Nagler DK. Review: novel cysteine proteases of the papain family. *Adv Exp Med Biol* 2000; 477:241-254.
2. Gerber A, Welte T, Ansorge S, Buhling F. Expression of cathepsin B and L in human lung epithelial cells is regulated by cytokines. *Adv Exp Med Biol* 2000; 477:287-292.
3. Kas J, Werle B, Lah T, Brunner N. Cysteine proteinases and their inhibitors in extracellular fluids: markers for diagnosis and prognosis in cancer. *Int J Biol Markers* 2000; 15:84-89.
4. Bank U, Kruger S, Langner J, Roessner A. Review: peptidases and peptidase inhibitors in the pathogenesis of diseases. *Adv Exp Med Biol* 2000; 477:349-378.
5. Guinec N, Fumeron VD, Pagano M. *In vitro* study of basement membrane degradation by the cysteine proteinases, cathepsin B, B-like, and L. Digestion of collagen IV, laminin, fibronectin, and release of gelatinase activities from basement membrane fibronectin. *Biol Chem Hoppe-Seyler* 1993; 374:1135-1146.
6. Frosch BA, Berquin I, Emmert-Buck MR, Moin K, Sloane BF. Molecular regulation, membrane association and secretion of tumor cathepsin B. *APMIS* 1999; 107:28-37.
7. Bossard MJ, Tomaszek TA, Thompson SK, Amegadzie BY et al. Proteolytic activity of human osteoclast cathepsin K. *J Biol Chem* 1996; 271:12517-12524.
8. Buhling F, Waldburg N, Gerber A, Hackel C, Kruger S, Reinhold D, Bromme D, Weber E, Ansorge S, Welte T. Cathepsin K expression in human lung. *Adv Exp Med Biol* 2000; 477: 281-286.
9. Leung-Toung R, Li W, Tam TF, Kariman K. Thiol-dependent enzymes and their inhibitors: a review. *Curr Med Chem* 2002; 9:979-1002.
10. Turk B, Turk D, Turk V. Lysosomal cysteine proteases : more than scavengers. *Biochim Biophys Acta* 2000; 1477:98-111.
11. Van Noorden CJF, Boonacker E, Bissell ER, Meijer AJ, Van Marle J, Smith RE. Ala-Pro-cresyl violet, a synthetic fluorogenic substrate for the analysis of kinetic parameters of dipeptidyl peptidase IV (CD26) in individual living rat hepatocytes. *Anal Biochem* 1997; 252:71-77.
12. Boonacker E, Van Noorden CJF. Enzyme cytochemical techniques for metabolic mapping in living cells, with special reference to proteolysis. *J Histochem Cytochem* 2001; 49:1473-1486.
13. Traganos F, Darzynkiewicz Z. Lysosomal proton pump activity: supravital cell staining with staining with acridine orange differentiates leukocyte subpopulations. *Methods Cell Biol* 1994; 41:185-194.